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THE ROLE OF PIPELINES IN
WORLD WAR TWO

by

CHARLES WENDELL ROBERTSON

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Approved by:

William R. Siddall

Major Professor

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INTRODUCTION

Transportation: An Instrument for Spatial Interaction

> Transportation is one of the tools required by civilized man to bring order out of chaos. It reaches into every phase and facet of our existence. Viewed from every standpoint, economic, political, and military, it is unquestionably the most important industry in the world. You can no more operate a grocery store or a brewery than you can win a war without transportation. The more complex life becomes, the more indispensable are the things that make up our transportation systems.[1]

Transportation, the movement of commodities, services, ideas, or individuals across space, is a geographically-necessitated activity, the development of which was originally derived from the demand by primitive groups for commodities of nature which could not be provided them all in one place. Even though the complexities of spatial movement have now evolved far beyond the simple supply-demand or complementary region situation, geographical necessity, though intermingled with other forces, is still a basis for spatial interaction. As will be illustrated later in this paper, the degree and type of spatial interaction which may occur between areas

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[1]Report of the Subcommittee on the Armed Services of the House of Representatives, quoted in National Transportation Policy, report prepared for the Committee on Interstate and Foreign Commerce, United States Senate, by the Special Study Group on Transportation Policy in the United States. (Pursuant to Senate Resolution 29, 151, 244 of 86th Congress, January, 1961.)

horizontally removed from one another will depend on much more than mere supply and demand. Such factors as the magnitude of demand, intervening opportunities for supply, and effective distance or ease of movement in virtue of the type of commodity being moved and the facilities available for its movement must also be taken into account.

The vehicle or conveyance which is employed for the purpose of moving goods or people across space from one place to another is termed a "transportation facility." The study set forth in this paper is to consider the spatial role of one particular type of transportation facility, the pipeline, in a particular situation, a wartime situation.

The Development of Pipeline Transport. The pipeline can be considered to be a rather recent innovation into the realm of vehicles that are used for spatial movement of commodities if one considers only the very rapid development of this conveyance for "long-distance" transportation within the middle decades of the twentieth century, for it was in this period that the major portion of the present world pipeline pattern developed, and for that matter is still developing today. However, if the situation is viewed more closely, it can be seen that the pipeline is one of the oldest inanimate transportation facilities in existence.

The early uses of the pipeline were generally for peaceful purposes rather than for purposes of war. The most common commodity carried, water, was employed in irrigation projects, for bathing, or for household use. "The Chinese are known to have made intensive use of pipelines constructed of connected bamboo trunks, 5,000 years before Christ."[2] The Babylonians and Assyrians also made use of various types of pipelines, as did the Romans, for the purpose of transporting water into the famous Roman Baths. "There are traces of clay tubes used for drainage purposes in sections of the medieval world when man's reasoning was employed to supplement natural surroundings."[3] Many of the kings of Europe, such as Louis XIV, had pipeline systems installed to provide their palaces with adequate water supplies.

It is interesting to note that most of these early pipelines were "short distance" lines that operated on the principle of gravity and served only a very limited area. The "long distance" pressurized type pipeline, which is the most common type in use today, did not come into existence until the advent of the petroleum industry in the United States in the second half of the nineteenth century.

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[2]"Pipelines and Pipeline Transportation," Transportation and Communications Review, V Number 4, 1952, p. 23.

[3]M. E. Conkling, "Pipelines in Industry," Petroleum Engineer, XV (March 19, 1944), p. 20.

The first oil well was drilled by Colonel Drake on Oil Creek near Titusville, Pennsylvania, in August, 1859. In the beginning there were two ways of moving oil out of the area--by boat and/or by wagon. "The fact that Oil Creek emptied into the Allegheny River made water transportation to Pittsburgh a natural avenue for the oil trade."[4] Many of the other wells in this early period, like the first one at Titusville, were drilled near streams and the oil was loaded into barrels, tubs, or onto barges and shipped downstream to the market area. But as the oil industry began to expand and new wells were drilled far removed from the streams and rivers, other means of transport had to be provided for the movement of oil. At first, horse-and-wagon teams were employed to move the oil from the wells sometimes 20 to 25 miles over very bad roads to streams or to newly constructed railway lines that soon appeared in the area after the big oil boom. This mode of transport, the horse-and-wagon, and even the movement of oil by waterway and railway, was extremely costly, unreliable and necessitated such complicated handling practices that "probably up to 30% of the cargo often could be booked as a loss."[5]

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[4] Arthur M. Johnson, The Development of American Petroleum Pipelines (1862-1906). (Ithaca, New York: Cornell University Press, 1956), p. 2.

[5] "Pipelines and Pipeline Transportation," op. cit., p. 24.

A more efficient and economical means of transport was needed, and this efficiency and economy was found in the pipeline, which provided an economical even flow system with a minimum of loss. From the construction of the first successful "long distance" pipeline, which was "2 inches in diameter and 5 miles long, built in 1865 from Pithole to Miller's farm in Pennsylvania,"[6] the American system expanded so that by the time of our entrance into World War One there had been developed "a pipeline system comprising 19,441 miles of crude oil trunk lines and 23,528 miles of gathering line, a total of 42,969 miles."[7] By 1920 total mileage had risen to 52,993 miles, by 1930 to 110,654, and by 1941 to 131,913, including crude oil lines, gathering lines, and products lines.[8]

In the period between the two world wars, the greatest expansion of pipeline mileage occurred in the southwestern and midwestern states of the United States, with an actual decrease in mileage taking place along the Atlantic seaboard. This decrease in mileage along the East Coast was not due to a decrease in total petroleum consumption in the area, but rather to a cost differential which existed between various

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[6] B. Dow Fayette, "The Role of Petroleum Pipelines in the War," Annals of the American Academy of Political and Social Science, CCXXX (November, 1943), p. 94.

[7] Ibid.

[8] Data is given here exclusively for the United States, since "long distance" line systems were largely absent from other world areas prior to World War Two, and an estimation of world pipeline mileage in this period has proved unobtainable.

types of oil shipping facilities. "It was . . . more economical to move oil by pipeline to the Gulf Coast and thence by tank ship to the refineries on the Eastern seaboard than through the older lines to the East Coast."[9]

With the advent of the war in Europe in 1939, and with an increase in German submarine activity in the Western Atlantic, the effective distance for tankers to carry highly inflammable cargo even in the coastal waters was increased. For that reason internal transport facilities such as the pipeline, the railroad tank car, and the river barge became the principal carriers of petroleum and petroleum products from the fields of production to the refinery and distribution centers. For the first time the "long distance" pipeline was used as a major transport facility during a period of full-scale war.[10] The use of the pipeline as a strategic carrier of war commodities was not to be limited merely to internal transport within the United States, but was also to become a major implement of military logistic strategy in many overseas areas and actually in some front lines operations in both the European and Asiatic theatres of war.

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[9]Fayette, loc. cit.

[10]Long distance petroleum pipelines were used on a limited scale to ship petroleum to the East Coast during World War One.

The Purpose of the Study

Since it appears that the pipeline did play a significant part in the war effort, and since no general study has been made of the pipeline to discover its role as a transport facility, the author feels that such a study will be useful to lead to a discovery of the pipeline's position as a facility for the implementation of commodity flow between areas horizontally removed from one another. The purpose of this study, then, is to collect, organize, and analyze various types of statistical data, maps, and other information, and in so doing develop a concept as to the role played by the pipeline as an integral part of the total transportation system of the allied powers.

Preview of the Content

The following organization will be employed in making such a study: Chapter Two, Transportation and War--Some General Considerations, will briefly explore the role of transportation in war and examine some of the problems encountered in organizing an optimum wartime transportation system. In Chapters Three and Four, The North American Pipelines and Military Pipelines--Europe and Elsewhere, a descriptive study of some of the more important facilities that were utilized in the war will be presented. Finally, Chapter Five, The Pipeline--An Integral Part of the Total Transportation Scheme, will be

devoted to analyzing the overall importance of the role that the pipeline actually played in the war in light of its character and utilization.

CHAPTER II

TRANSPORTATION AND WAR--SOME GENERAL CONSIDERATIONS

> In a tale of war, the reader's mind is filled with fighting. The battle--with its vivid scenes, its moving incidents, its plain and tremendous results--excites imagination and commands attention. The eye is fixed on the fighting brigades as they move amid the smoke; on the swarming figures of the enemy; on the General, serene and determined mounted in the middle of his staff. The long trailing line of communication is unnoticed. The fierce glory that plays on red, triumphant bayonets dazzle the observer; nor does he care to look behind to where, along a thousand miles of rail, road, and river, the convoys are crawling to the front in uninterrupted succession. Victory is the beautiful, bright colored flower. Transport is the stem without which it could never have blossomed.[11]

This passage, written by Winston Churchill in The River War, stresses the profound connection which exists between the existence of an adequate transport net and defense capability. Because such a close relationship does exist, the author thinks it necessary to begin his study by devoting a chapter to the presentation of a general overview of several factors which may be helpful to the understanding of the role of transportation in war; and by gaining a better understanding of the greater role played by the composite transportation system, it is hoped that a better understanding may also be gained when the study is narrowed to the more specific topic of the role

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[11]Henry E. Eccles, Logistics in the National Defense, as quoted from The River War (Harrisburg, Pa.: Stackpole, Co , 1959), p. 1.

of pipelines in war. The two sets of factors chosen for discussion herein, and it is hoped that these factors represent in their brevity a true essence, are the following: A study of the growing importance of transportation as an integral part of the total wartime effort and an examination of the various problems faced by the total transport system, such as dislocation in demand, redistribution of commodity flow, and problems of organization for the direction and control of transportation.

The Increasing Importance of Transportation in Warfare

The importance of an adequate transportation system to success or failure in military ventures or conquests dates to antiquity. For example, the Romans developed a very complex system of roads whereby, because of the resulting ease of movement from place to place, they were enabled to hold military, political and economic control over most of the known world of that day. However, because of a deficiency in one portion of the total transportation system, this prominent position was almost sacrificed. Even though the Romans had a highly-developed land transportation system, they lacked sea power. The Carthaginians, who were Rome's chief rivals for world power and who were also quite efficient sailors, were cognizant of Rome's water transport weakness,

and began to plan a naval engagement against Rome. The Romans, becoming aware of this weakness in its transport system, devoted intensive effort to its correction and by so doing defeated the Carthaginian sailors.[12]

One of the factors that probably contributed to the failure of Napoleon I in his march across Europe was the inadequacy of the transportation system of the area. Napoleon failed to consider the factor of "effective distance" or the ability to move a particular distance, in a particular length of time, in accordance with the type of transportation facilities available. Napoleon arrived in Moscow in midwinter 1812. Finding the city deserted and being unable to transport supplies into the area because of the great distance involved, he was obliged to retreat. In making this withdrawal, he was forced, due to the difficulty of moving across the muddy roads of Eastern Europe, to leave most of his heavy equipment behind.[13]

Even though the nature of available transportation has contributed greatly to the decisive outcome of the course of events of some of the classic military campaigns of history, it was not until that period following the advent of the Industrial Revolution that transportation began to acquire the important role which it has today in the total military machinery.

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[12]Lionel Casson, The Ancient Mariners (New York: Macmillan and Company, 1959), p. 157-172.

[13]Lt. Gen. B. B. Somervell, "U. S. Army Services of Supply," Academy of Political Science, Proceedings, XX (January, 1943), p. 164.

The "Industrial Revolution," sometimes referred to as the "transportation revolution," greatly affected the nature of warfare, and the changed nature of warfare in turn created for transportation a new role which it had not possessed before. Modern warfare has become a "war of movement"[14] instead of a war of position as it once was. This "war of movement" in actuality is an outgrowth of the Industrial Revolution. Advancement in technological development brought "mass production of munitions and foodstuffs, the railroad, the steamship, the long-distance pipeline, the internal combustion engine, eventually the transport airplane."[15] And these in turn contributed the element of speed to the movement of troops and military supplies.

Increase in speed of movement broadened the scope of warfare and military campaigns became complicated and expensive endeavors, whereas at one time they were, in general, rather simple endeavors confined to limited areas. Rear Admiral Henry E. Eccles in Logistics in the National Defense stresses the importance of the contributions of the Industrial Revolution, particularly those in the field of transportation, to changing the nature of warfare. Eccles states that in the latter part

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[14]Joseph B. Eastmen, "Performance of the American Railroad," Academy of Political Science, Proceedings, XX (May, 1942-January, 1944), p. 102.

[15]Office of the Chief of Military History, Department of the Army, "Global Logistics and Strategy, 1940-43," United States in World War II (Washington: U.S. Government Printing Office, 1955), p. 4.

of the 18th century the Industrial Revolution began to greatly influence the nature of warfare. "By 1860 the railroad, the steamship, and improved firearms were the most obvious military fruits of the large scale, organized use of coal, iron, and industrial machinery which characterized the first phase of the Revolution."[16] The latter decades of the 19th century saw the increased development of the electrical and chemical industries and the internal combustion engine. It was these developments that formed the industrial background for World War One.

Finally, World War Two brought a climax to the pre-nuclear phase of the scientific industrial revolution. "The mass use of the internal combustion engine, of aeronautics and electronics, and the advancement in chemical explosives provided weapons and equipment of tremendous range, speed, and power."[17]

Wartime Transportation Problems

In considering the role of transportation in war, it should be stressed that transport and transport planning encompasses much more than the logistical strategy employed for the movement of people and commodities to, within, and from the actual combat area. Factors such as the movement of raw material to war production plants, the movement of semi-

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[16] Eccles, op. cit., p. 6.

[17] Ibid, p. 7.

finished or finished products to points of fabrication, use or embarkation, the movement of war workers to and from work, in addition to the supply of the civilian population with essential commodities, must also be taken into account.

Because of the multiplicity of demands and the complexity involved in supplying these demands, a wartime transportation system will be burdened with many difficult and sometimes unique problems.

A nation's ability to confront new situations that are created as a result of the occurrence of warfare may be closely correlated with that country or area's state of economic development. For example, there seems to be a covariation between the stage of industrialization of a nation and the degree to which that nation has developed its transportation system. It is, of course, difficult to discern whether the growth of industrialization in a nation is the result of the favorability of a pre-existing transportation system, whether the establishment of a highly-developed transportation system is the result of the demands made by an expanding economy, or whether each complements the other in its growth and development. Whatever be the case, the construction of a highly-developed transportation system, one that will meet the demands of a wartime situation, requires a tremendous amount of investment capital. And a nation which is economically developed is more likely

to have surplus investment capital available than a nation which has limited development in the fields of industrialization, commerce, or utilization of natural resources.

The economic situation of an area will not necessarily fully indicate the scope of transportation problems or the manner in which the problems will be approached for solution. The political situation may largely indicate the general attitude and approach that will be taken.

One of the situations with which an area will likely be confronted during a war, as will be discussed later, is the problem of organization for direction and control of transportation. The type and extent of organization will depend largely upon the nature of the political system of any given area. For instance, in some areas, especially those with a democratic political system, the government may act mainly in the capacity of a co-ordinator endeavoring to maintain a balanced flow of commodities via the available transportation facilities, encouraging the expansion of private transportation through favorable legislation or other supporting measures, and attempting to balance supply and demand so that the civilian and military segments will each enjoy a fair share of the total available supply. On the other hand, the policy may be less benevolent and the military may receive prime consideration at the expense of the civilian

or private segment. This should not be construed to mean that under a system of benevolent government control the civilian segment will not have to endure hardship, because it is evident that self-restraint and abstinence are often required. But this should be viewed merely as an illustration that the policy of organization and direction of commodity flow may tend to differ among differential political systems. It should also be noted that in the actual field of military operations coordination and control of transport facilities will likely be a part of strategic logistic planning, and the available facilities will more than likely be employed in the manner that will best meet the logistically planned end.

A third factor which should be considered in relation to the complexity and extent of transportation problems is the factor of technological change. An area that may have been adequately prepared to meet transport demands during one period of time may find itself ill prepared during another period simply because of technological lag or stagnation. As the techniques of warfare have advanced, especially since the beginning of the Industrial Revolution, many new commodities have become strategically important, and new military methods and weapons have been initiated as a result of technological change and invention. As the transport of these new commodities becomes a strategic necessity and as new military methods and

weapons are initiated, it is found that the existing transport system of an area may not be well adapted or may be inadequately prepared to meet the demands which are made of it. For instance, the increased demand for petroleum, which has become a strategic commodity of modern warfare growing out of technological development, and the initiation of new vehicles of warfare, such as the submarine, introduced many variables to the field of transport with which it had not hitherto been confronted, as will be illustrated in the following chapter.

Finally, it can be pointed out that the spatial arrangement of an area may also affect the complexity and extend of transport problems. Territorial expanse, distribution of population, opportunities for coastwise and inland water transport, the distances of industrial centers from raw materials and fuel supplies,[18] and the "effective distance" of an area in relation to the field of actual military operations are factors which may affect in one degree or another an area's transport problem complexity.

Although the complexity and nature of transport problems will differ from area to area according to the interrelation of the factors of spatial arrangement, technological advancement, political philosophy, or economic

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[18] Klaus E. Knorr, The War Potential of Nations (Princeton: Princeton University Press, 1956), p. 183.

development, there are nevertheless certain typical problems that may develop. Such problems may involve change in demand dislocation of the supply carrying capacity, the redistribution of commodity movement, or problems of organization for the direction and control of transportation.

One of the most apparent problems which confronts a nation's transport system when that nation becomes involved in the activity of warfare is the marked change in demand made of the available facilities. In some nations in the past, it is found that the transport system, particularly the civilian transport system, has been more often than not designed to serve the normally expanding economy of the industry and commerce of the nation; and little thought has been given to the demands that might be made of that transport system should a major war occur. During periods of peace, the military traffic is usually a small percentage of that of ordinary commerce; and national defense may require few facilities beyond those established for the peacetime commercial pursuits provided some slack does exist in the system.[19] Of course, nations that stress the development of military power for defensive of offensive purposes may have a transportation reserve oriented around such power; and, if this be

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[19] L. C. Sorrell, "Transportation and the National Defense," Journal of Business of the University of Chicago, XIV (1941), p. 237.

the case, that nation may be well prepared if a defense demand situation arises. However, a transport system which is oriented only toward serving immediate commercial or projected commercial needs may prove inadequate in a wartime situation.

Increase in Demand

First of all, the transport system may experience an increased volume of business "which results from superimposing on the necessary civilian traffic a large military load, much of which requires preferential movement."[20] The total increase in traffic which results cannot be calculated by merely estimating the total quantity of commercial goods to be moved with the addition of military supplies, but is to be calculated rather by taking into account the commercial freight to be shipped "plus an increment therein deriving from the increased volume of business activity,"[21] which is usually to be expected with the advent of war, plus the calculated military movement, "and minus such losses as will follow the curtailment of non-essential industries and activities."[22]

Not only will there be an increase in demand taxing the capabilities of the transport system, but there is also likely to be a "conflict" in demand arising from the competitive

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[20] Herbert Ashton, "Problems of Wartime Freight Movement," Annals of American Academy of Political and Social Science, CCXXX (November, 1943), p. 13.

[21] Sorrell, loc. cit.

[22] Ibid.

needs of the civilian and military segments. This conflict may largely be due to the inability of a limited transport system to meet the total demands of both segments, and priority may have to be given to the one deemed most important at the moment.

Dislocation of the Supply Carrying Capacity

A second problem that may develop is the occurrence of a dislocation of supply carrying capacity, and this dislocation may give birth to still another problem, the redistribution of commodity movement. In a period of war, the supply carrying capacity of certain transportation facilities may be diverted to transporting commodities other than those more commonly transported or to carrying larger quantities of certain commodities at the expense of reducing the supply carrying capacity for other commodities. Also, it is possible that the effective distance of moving commodities via particular modes of transport may be increased to such an extent that other facilities must be substituted. The following passage from a report by the United States Bureau of the Budget illustrates the transport dislocation which occurred with the coming of World War Two.

> The swift advance of the Japanese on the rubber producing areas, sinking of coastal vessels--especially tankers, growing shortage of gasoline on the eastern seaboard, orders stopping the manufacture of motor vehicles for civilian use, manpower shortages in the transportation field, curtailment of civilian air traffic, growing obsolescence of railway equipment and rationing of tires, automobiles and gasoline brought home to all the transport dislocations of a many-front war.[23]

An excellent example of the problem of transport dislocation and traffic diversion during the war is that which occurred along the coastal shipping lanes of the United States. However, to eliminate duplication, this subject will not be discussed at present, but will be examined later in Chapter Three under "Pipeline of the United States."

Problems of Organization for the Direction and Control of Transportation

The development of the problems of dislocation in demand and supply carrying capacity may contribute to the development of still another problem--the problem of organization and coordination of transportation facilities.

In earlier paragraphs, it was pointed out that the nature and extent of control or organization will probably differ from area to area depending upon need or possibly upon political policy. Even though this variation exists, there may be some typical cases which call for some type of organization

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[23]United States Bureau of the Budget, United States at War, prepared under auspices of the committee of records of War Administration by the War Records Section (Washington: United States Government Printing Office, 1946), p. 155.

and control. Two of the most typical are: controlling the relationship between the government buyer and the seller of transport services and organizing the civilian and military demand.[24]

In the first case, if the government is both the buyer and seller of transportation, then only a minimum of additional organization will probably be needed to coordinate the government purchase of transport service for military purposes with the government sale of such services, since the owner and seller are one in the same. Of course, some value judgment will have to be made as to how much will be allocated to the military in light of a counter civilian demand that will more than likely also be present.

If the government, in the purchase of transport services, must rely on purchasing such services from private rather than public sources, then coordination of purchase demand with saleable supply may become quite a problem of organization. Although a government may not actually own the transport carriers operated within its jurisdictional limits, it is usually desirable that a degree of centralization of authority be obtained

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[24]Sorrell, <u>op. cit.</u>, p. 251.

> in the government military bureaus, and over the various private transport companies, that the former will not be under the necessity of dealing with a multitude of suppliers, and the latter may avoid the inconsistent and uncoordinated decisions of the former.[25]

In other words, a type of central coordination must be effected so that a working relationship can be established between the seller of carrying services and government purchasing agencies in such a manner that the availability of transport carriers for given tasks at given times may be ascertained, and effective mobilization can be procured on rather short notice.

A notable example of centralized coordination in the field of domestic transportation was the establishment of the Office of Defense Transportation by Executive Order in December, 1941.[26] The O.D.T., as it was referred to, was authorized to coordinate the policies and activities of the various transport carriers--railroad, motor vehicle, inland waterway, pipeline, air transport, and coastwise shipping. It was also authorized not only to keep close watch on domestic transportation, but to protect the interests of such transportation from undue infringement by other agencies of the government and do all that was possible to "promote the maximum utilization of transportation facilities."[27] By this arrangement, each of the transport facilities operated under its own

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[25] Ibid., p. 250.

[26] Executive Order No. 8989.

[27] Bureau of the Budget, op. cit., p. 158.

industrial management, and the O.D.T. had policing power, rather than managerial power, to "cover every means of transportation and penetrate to every detail of the operation in so far as it affects the war effort."[28]

The second case of transport organization, the coordination of civilian and military demand, usually stems from the fact that a conflict of demand may develop when only a limited transport capacity is available or when a dislocation of supply carrying capacity has taken place, and some system of priority must be developed and enforced so that the most beneficial use can be made of the facilities which are available. In some areas, as has been pointed out, the policies of coordination may be such that the military demand will be supplied largely at the expense of a neglected civilian demand. But usually, however, civilian demand for transport services will not be "entirely" neglected, and at least a minimum of service must be afforded to the partial fulfillment of this demand. Just what portion of the civilian demand is most important and just what portion of this demand is supplied will largely be left to the discretion of the planning agencies. This discretion, of course, may differ according to the nature of the strategic plans or military objectives which have been laid down.

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[28]Ashton, op. cit., p. 14.

CHAPTER III

THE NORTH AMERICAN PIPELINES

In the immediate chapter and in the following one, an attempt will be made to present an overview of the major pipelines that were employed as facilities for the movement of commodities strategic to the allied war effort. Among these facilities it will be found that some were employed purely as military facilities, while others served the dual purpose of supplying both domestic and military demand.

The subject matter of Chapter III will be confined to the discussion of North American pipelines and petroleum commodity flow. The author thinks it necessary to devote an entire chapter to this area since this is the area of the world in which the most extensive system of pipelines was present at the beginning of World War Two and the area which depended most on the pipeline as a facility for both domestic and military use.

Two topic subjects will be considered herein: Pipelines of the United States and the Canol Project. The space allotted to Pipelines of the United States will be quite lengthy for this section will be utilized to illustrate the concepts that were presented in the previous chapter. In the remaining sections of this chapter and those of the following an attempt

at such detailed application will not be made and therefore those sections are much less lengthy. However, this does not necessarily mean that the same or similar concepts cannot be or will not be applied; but in some cases where the application of concepts can be inferred from the descriptive material, no attempt will be made to spend lengthy passages making such application.

Pipelines of the United States--East Coast Petroleum Supply

Since the total pipeline system of the United States at the beginning of World War Two was vast and complex and since an analysis of the entire system is almost prohibitive in the space herein allotted, the author has chosen to limit his discussion to East Coast petroleum supply, for it was in this area that the pipeline probably played its most crucial role.

The Spatial Arrangement. To understand the factors involved in petroleum commodity flow to the East Coast, it seems necessary to develop a basic concept as to the major areas of petroleum production, the pattern of consumption, and the methods of transport employed to move the commodity from the areas of production to the areas of consumption in the pre-war years.

Table 1 contains data of the production of crude petroleum by state for the years 1940-1946. Among the leading twenty-one crude oil producing states in 1940, all of them, with the exception of California, Michigan and Illinois, were situated in an area between the Rocky Mountain system on the west and the Mississippi River on the east. These seven states, with the addition of Michigan and Illinois, accounted for approximately 80% of total United States crude oil production in 1940; and with the addition of California, the ten leading states accounted for approximately 96% of total United States crude oil production. It is also interesting to note (see Table 1) that only one of the states, Pennsylvania, generally designated as an eastern seaboard state, appeared on the list of the leading crude petroleum producers. And it accounted for only 1.3% of total production in 1940, dwindling to barely more than 1% in 1943.

The twelve states of New England and the Middle Atlantic Coast which produced less than 2% of the crude oil of the United States in turn consumed more than 40% of the total consumed petroleum fuels in the period prior to the war (based on 1938 and 1939 statistics) and approximately one third of United States consumption of petroleum fuels during the war years. It is then evident, in comparing crude petroleum production with consumption, that the petroleum fuel consumption

TABLE I

U. S. Production of Crude Petroleum, By States
(Thousands of Barrels)

State	1946	1945	1944	1943	1942	1941	1940
Alabama	380	181	43				
Arkansas	28,375	28,613	29,418	27,600	26,628	26,327	25,775
California	315,179	326,482	311,793	284,188	248,326	230,263	223,881
Colorado	12,016	5,036	3,083	2,320	2,199	2,150	1,626
Illinois	75,297	75,094	77,413	8,260	106,391	132,393	147,647
Indiana	6,726	4,868	5,118	5,283	6,743	7,411	4,978
Kansas	97,218	96,415	98,762	106,178	97,636	83,242	66,139
Kentucky	10,578	10,325	9,621	7,883	4,534	4,762	5,188
Louisiana	143,303	131,051	129,645	123,592	115,785	115,908	103,584
Michigan	17,074	17,267	18,490	20,768	21,754	16,359	19,753
Mississippi	24,216	19,062	16,337	18,807	28,833	15,327	4,400
Montana	8,801	8,420	8,647	7,916	8,074	7,526	6,728
Nebraska	265	305	417	635	1,237	1,898	276
New Mexico	36,860	37,351	39,555	38,896	31,544	39,569	39,129
New York	4,863	4,648	4,697	5,059	5,421	5,185	4,999
Ohio	2,908	2,828	2,937	3,322	3,543	3,510	3,159
Oklahoma	134,497	139,299	124,616	123,152	140,690	154,702	156,164
Pennsylvania	12,996	12,515	14,118	15,757	17,779	16,750	17,353
Texas	760,505	754,710	746,699	594,343	483,097	505,572	493,209
West Virginia	2,929	2,879	3,070	3,349	3,574	3,433	3,444
Wyoming	38,304	36,219	33,356	34,253	32,812	29,878	25,711
Other states	134	87	69	52	45	63	71
U. S. Total	1,733,424	1,713,655	1,677,904	1,505,613	1,386,645	1,402,228	1,353,214

Source: Petroleum Facts and Figures, Eighth Edition, 1947, p. 55.

demand of the East Coast states was greater than the production of crude oil from which the petroleum fuels were refined. Therefore, it is logical to assume that the area was forced to supply its demand from other sources. This demand could be supplied in two ways: from domestic or from foreign sources. By examining supply and demand statistics, it can be seen that foreign sources supplied only a small percentage of total demand.[29] Therefore, since foreign sources supplied such a small percentage of total demand, it is then reasonable to assume that the eastern seaboard states would obtain the larger portion of their total supply from the oil producing regions to the west, creating a need for interaction or complementary movement between the area of production and that of consumption.

Commodity Flow Pattern. The next question which should be asked is: What facilities were utilized in the implementation of the spatial flow of petroleum commodities between the western producing areas and the eastern states. In the period preceding the war, about 95% of all petroleum deliveries to the eastern states were shipped via coastal tankers and a few barges originating from Gulf ports. Railroad tankcars, pipelines, and other facilities accounted for only 5%. (See Figure 1)

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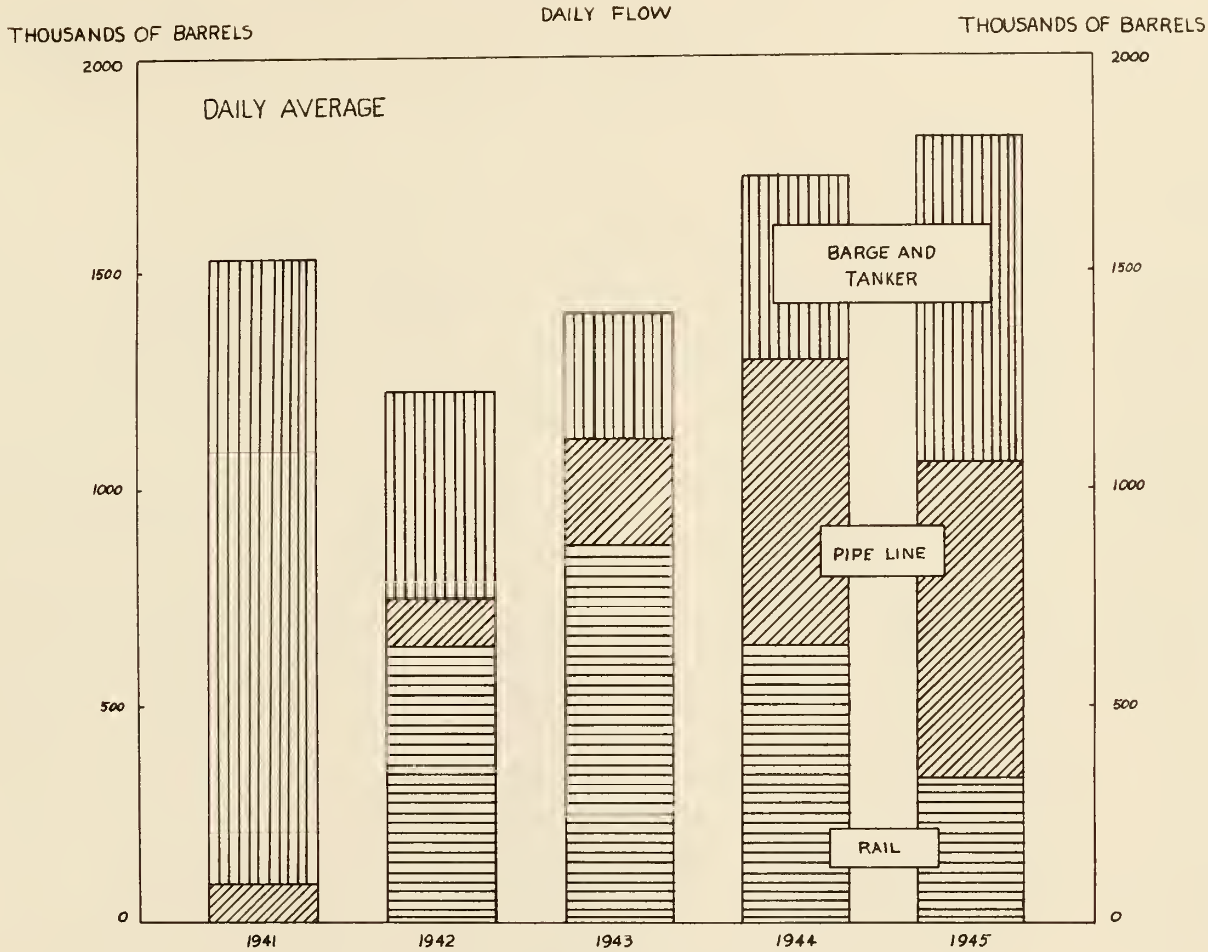
[29] Of the total domestic demand in 1940, 5% was supplied by foreign imports; in 1943, about 3%. Petroleum Facts and Figures, Eighth Edition, p. 10.



Petroleum Shipments to Eastern States
Including the New England, Middle Atlantic, and South Atlantic States
and the District of Columbia. (Sources Bureau of Buget "U.S. at War" p. 155,
Petroleum Administration for War p. 83 fig. B)

Figure 1

With the development of the war, there was a rearrangement of the flow pattern. For instance, by 1943 barges and tankers accounted for less than 20% of such shipments, whereas rail tank cars were carrying more than 50% and pipelines approximately 25%. By April, 1945, in the later stages of the war, pipelines accounted for 40% of the delivery, tank cars 30%, and barges and tankers approximately 30%. It will be the purpose of the following section to analyze the factors which contributed to this rearrangement of traffic flow, particularly those that contributed to the increased use of the pipeline.

In the Introduction, it was stated that between the two world wars United States pipeline mileage more than doubled so that by 1941 there was 67,649 miles of crude oil trunk lines, 9,903 miles of refined oil trunk lines, and 54,361 miles of crude oil gathering lines, or a total of 131,913 miles of all types. The gathering lines carried petroleum from the well area to storage centers, trunk pipelines, or railroad loading areas; the crude oil trunk lines carried the petroleum from the gathering centers to refineries or ports; and the gasoline trunk lines extended from the refineries or ports to points of distribution. "The location of gathering lines is determined by the location of oil wells, but the trunk lines are dependent also upon refineries and markets."[30]

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[30]National Resources Planning Board, Transportation and National Policy (Washington: U.S. Government Printing Office, May, 1942), p. 458.

Figures 2 and 3 illustrate the spatial distribution of crude oil and gasoline trunk lines in the pre-war era. The most outstanding feature of Figure 2 is the heavy concentration of crude oil lines in the southwest, midwest, and in California, with a conspicuous absence of such lines in other areas. The rapid growth of pipeline mileage did not include an expansion of mileage to the East Coast. In fact, in this period there was actually a decrease in pipeline transport capacity with many pipelines being abandoned or taken up. And many of the pipelines that continued to be utilized had a reversed flow of traffic moving petroleum westward from the coast toward the interior rather than in the ordinary flow pattern from west to east. This reduction in flow toward the coast was not due apparently to a decrease in consumption in the area, for, as has been pointed out, this area had a demand for about 40% of the total petroleum consumption of the United States and the total consumer demand in 1941 was about 3.5 times greater than the consumer demand in 1918.[31]

The reduction of commodity flow via pipeline in the interval between the two wars can largely be explained from the viewpoint of production distribution and cost differential of movement. During the first three decades of this century,

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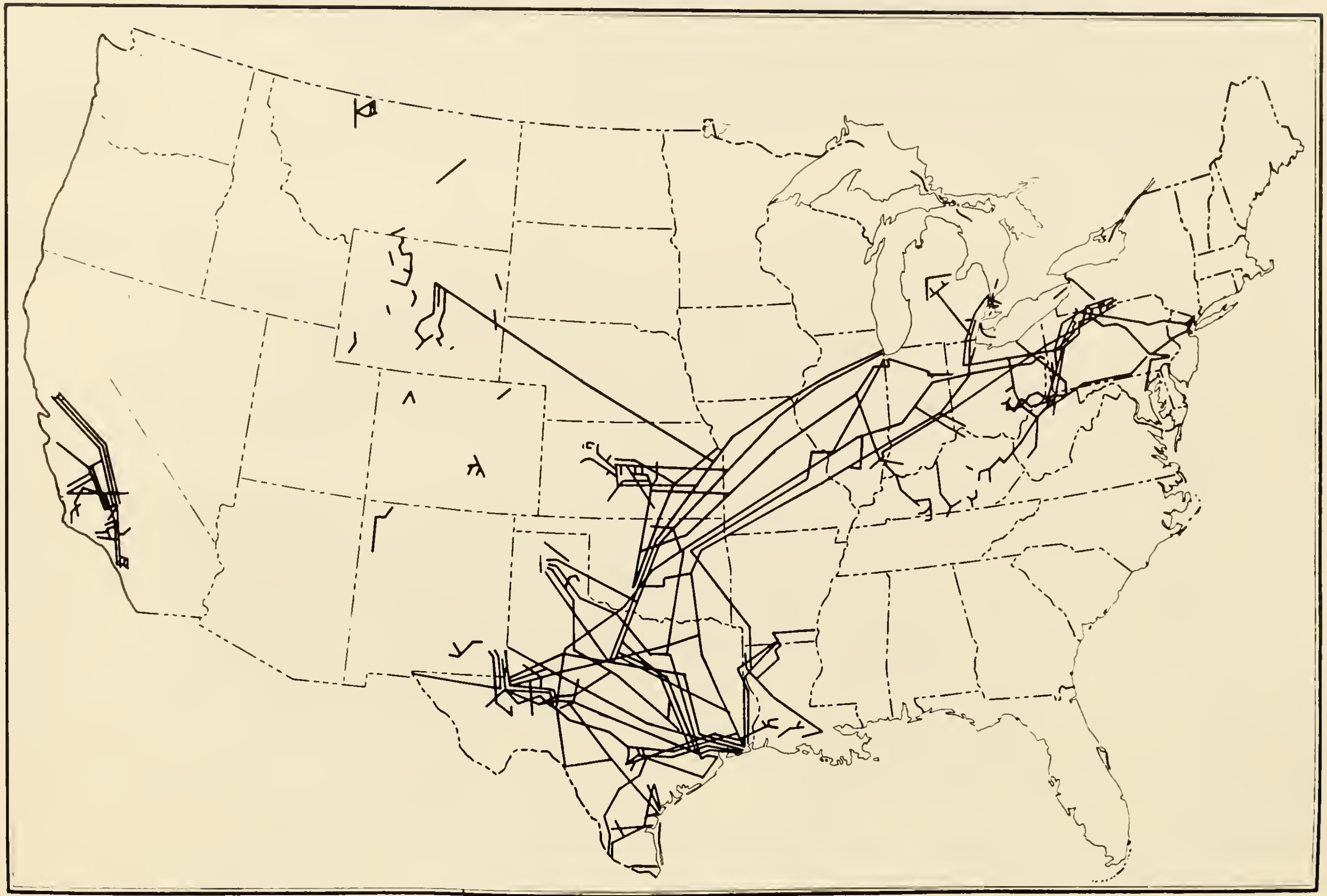
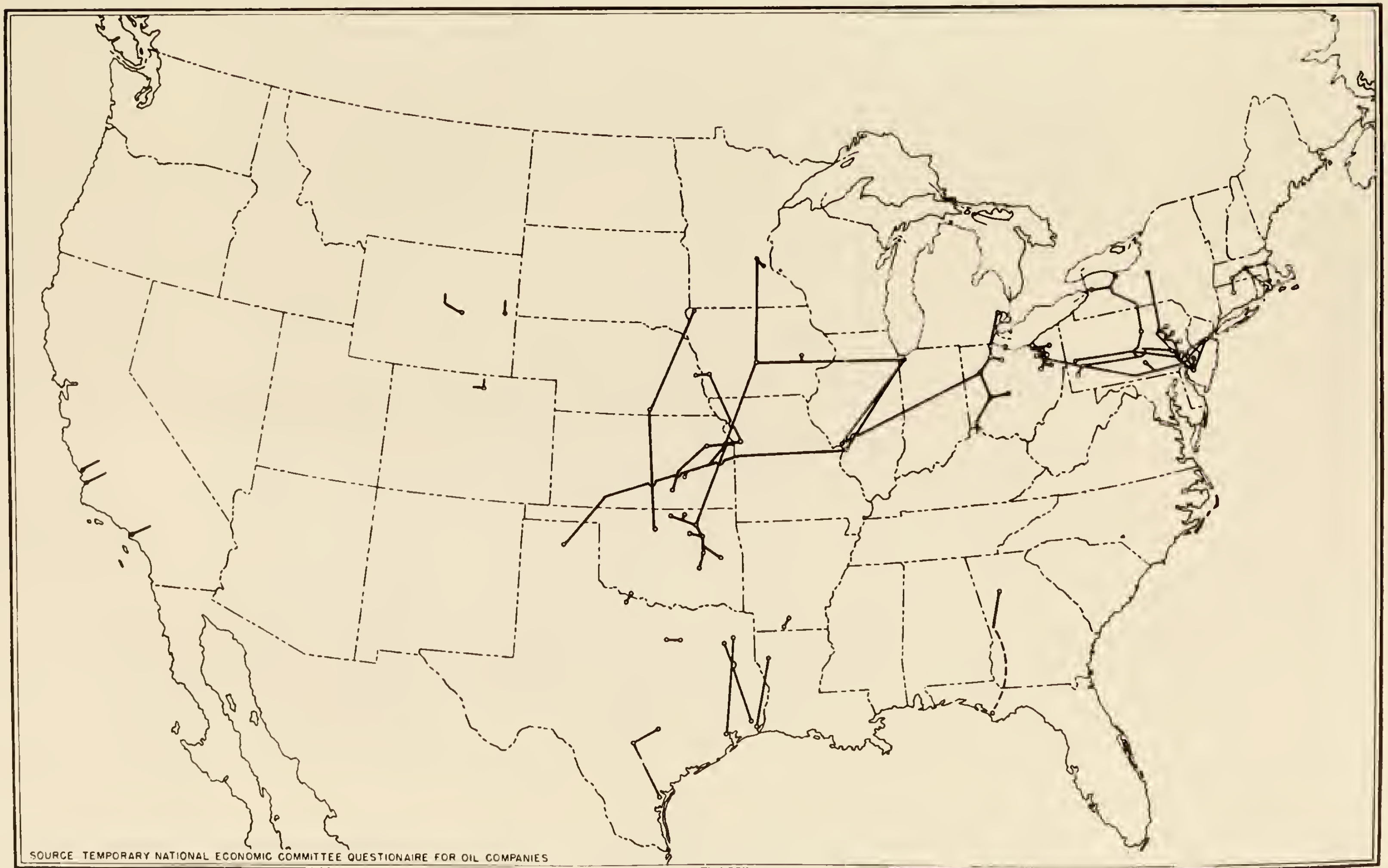
[31]Fayette, _op. cit._, p. 95.



Prepared in office of the National Resources Committee

CRUDE OIL TRUNK PIPELINES IN THE UNITED STATES – 1939

Figure 2



PREPARED IN OFFICE OF THE NATIONAL RESOURCES COMMITTEE

Gasoline Pipelines in the United States— 1940
Figure 3

there was a trend for petroleum production to shift more and more to the southwest and eventually Texas became the primary producing state. (Texas, Oklahoma, and Louisiana produced more than 50% of the crude oil in this period.) The southwest production region was conveniently located in relation to the Gulf Coast ports both in terms of actual distance and in terms of transport cost. The data below are approximate average total cost estimations of transport by pipeline, railroads, tanker, and truck based on pre-war figures.[32]

Railroad	8.3	mills/ton mile
Pipeline	3.2	mills/ton mile
Tanker	.7	mills/ton mile (gasoline)
Tank Truck	30	mills/ton mile (hauls 100 miles or more)

> Economics then confined the eastern movement of Petroleum by railroad tank cars to relatively small volumes of special products and the flow of oil in pipeline systems in the East was mainly in a westerly direction to inland destinations.[33]

In view of transport cost differential, it is not surprising that the definite flow pattern developed of transporting petroleum by pipeline to the Gulf ports and then by coastal tanker to the East Coast where it was then unloaded and distributed to refineries or market areas.

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[32]National Resources Planning Board, op. cit., p. 469.

[33]W. Alton Jones. "Wartine Revolution in Petroleum Transportation," World Petroleum, XIV (April, 1943), p. 31.

Factors of Dislocation. With the coming of World War Two, a definite dislocation and redistribution of petroleum commodity flow occurred. In 1941, tankers transported 430,769,000 barrels of petroleum products from the Gulf Coast to East Coast ports. (See Table 2) The following year, 1942, this flow was reduced by about 70%, and by 1943 the total petroleum carried by tanker was only about 15% of what it had been in 1941. It should also be noted that there was an actual decrease in the total quantity of petroleum flowing to the East Coast during this period.

Two factors are basically responsible for the reduced flow by tanker: the diversion of tankers to other areas in support of the war effort and submarine activity in the Atlantic. Beginning with January, 1941, tankers carrying petroleum between the Gulf and Atlantic Coasts were diverted to other areas to replace tankers with foreign flags that had been taken out of service. In May, 1941, 50 more carriers were diverted into British service to replace the 182 that she had lost to the enemy. It was expected that this loss of tanker service would be recovered within a few months as soon as new tankers were built to replace them.[34] However, with the occurrence of Pearl Harbor and the development of the

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[34]See Hearings before the Special Committee to Investigate Gasoline and Fuel Oil Shortages, United States Senate, 77th Congress, Pursuant to Senate Resolution 156, p. 193.

TABLE II

Tanker Movement of Petroleum Products From
U.S. Gulf Coast to East Coast Ports
(Thousands of Barrels)

Product	1946	1945	1944	1943	1942	1941	1940
Crude Oil	191,682	73,502	14,248	4,988	30,803	147,288	162,063
Gasoline	123,967	48,793	23,133	22,431	33,753	130,534	119,142
Kerosine	34,335	13,228	5,185	5,116	8,999	25,300	27,262
Gas oil and Distillate	68,851	28,175	13,123	14,832	20,341	42,620	44,429
Residual fuel oil	55,186	37,192	20,453	13,046	27,149	75,923	67,346
Lubricants	6,600	1,024			2,130	8,148	7,463
Other products	2,790	2,177	194	854	639	956	616
Total	483,411	204,091	76,336	61,267	123,814	430,769	428,321

Source: Petroleum Facts and Figures, Eighth Edition, 1947, p. 147.

war front in two oceans, the number of transport ships and supply ships demanded by the navy began to increase. "It became evident that it would be necessary to divert tankers in increasing number to the movement of fuels for the fleets, to various bases established overseas for the armed forces."[35] In addition, with the entrance of the United States into the war there was an increase in German submarine activity along the Atlantic Coast. In the first two months the submarines caused little damage, but between February and May the enemy sank 50 tankers along the Coast. "From then on until the last year of the war, tanker deliveries were an insignificant factor in supplying the oil needs of the East Coast."[36]

The dislocation of the major petroleum transport facility deemed it necessary to redistribute the commodity flow to other facilities--that is, if the ordinary demand was to be supplied. As was concluded earlier, a definite redistribution did take place, as did a definite decrease in the total quantity of petroleum being shipped. It was not until 1944 that the total movement again equaled the pre-war movement.

To understand the pattern of redistribution, it is necessary to examine the factors of organization and coordination. The dislocation of supply carrying capacity created the

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[35]"War Emergency Pipeline," World Petroleum, XIII (December, 1942), p. 32.

[36]John W. Frey and H. Chandler Ide (eds.), A History of the Petroleum Administration for War, (Washington: U.S. Government Printing Office, 1946), p. 87.

need for substitution to fill the supply gap. The need for substitution, in turn, inevitably created the necessity of planning and co-ordinating a new transport pattern. And the necessity of planning and co-ordinating a new transport pattern involved the solution of such problems as: determining which facility or facilities best fit the immediate need, what type of integration of facilities should be effected, should new facilities be constructed, and if so, what type should they be.

Filling the Supply Gap. When the dislocation in tanker traffic posed the problem of redistribution, "the rails offered the most rapidly expansible substitute."[37] At the beginning of the war, 1941, there were slightly more than 160,000 private and railroad owned tank cars in service in the United States (See Table 3) of which approximately 149,500 were being used in the petroleum transport service. When a petroleum shortage emergency becams apparent in the Eastern states, "thousands of tank cars were drafted from regional service throughout the country and assigned to East Coast service."[38] By the end of 1942, the total number of tank cars in service increased by only 2% over 1941 while

[37]Jones, op. cit., p. 30.

[38]In 1941 there were only 200 tank cars in service to the East Coast, by 1943 this number had risen to 70,000. "Two Pipelines for Sale," Fortune, XXXI (January, 1945), p. 126.

TABLE III

U. S. Railroad Tank Cars in Service

Year	In Petroleum Service Private	In Petroleum Service Railroad	Other Service	Total
1947	146,872	12,200	11,389	170,461
1946	146,665	12,028	11,354	170,037
1945	143,016	12,058	11,766	166,840
1944	142,226	12,109	10,928	165,263
1943	143,598	12,300	12,160	168,158
1942	139,437	11,819	11,924	163,180
1941	137,751	11,744	10,799	160,294
1940	135,854	12,065	18,629	166,548
1939	134,034	12,365	18,389	163,788
1938	143,797	12,888	15,403	172,088
1937	141,051	12,769	14,467	168,287
1936	141,438	12,987	13,450	167,875
1935	143,911	13,194	13,504	170,609

TABLE III (continued)

Railway Tonnage of Petroleum, By Products
(Carload freight only; tonnage
originated on lines)

Product	1945	1944	1943	1942	1941
Crude Petroleum	10,505,776	16,337,338	24,890,590	21,179,792	7,317,674
Petroleum Oils (refined)	28,158,149	30,224,416	25,605,093	30,443,361	36,217,258
Fuel, road, and residual oils	16,552,992	20,889,499	23,188,141	19,290,091	14,573,477
Lubricating oils and greases	6,030,063	5,837,825	5,689,601	4,642,176	4,179,142
Products not other-wise specified	521,531	642,972	672,596	401,770	383,562
Asphalt	5,224,748	5,043,405	4,829,234	5,860,945	6,652,272
Total Petroleum Freight	67,003,259	78,975,455	84,875,255	81,818,135	69,323,685
Total All Carload Freight	1,404,080,159	1,471,366,021	1,462,314,059	1,403,611,665	1,209,599,423

the amount of petroleum shipped by rail increased by about 16%. This large increase in petroleum shipment in relation to the increased number of tank cars in service can partially be contributed to the system of coordination that was developed to bring about the maximum utilization of equipment.

> Moving crude and petroleum products [on a seven day a week, twenty-four hour a day basis] in solid trains, non-stop from producing and refining centers to bulk distributing points in the East, the railway companies . . . increased the daily movement of oil from 10,000 barrels to over 800,000 barrels (1943), an achievement that was pronounced impossible before Pearl Harbor.[39]

Despite this intense implementation and utilization of railway tank cars, "a shortage of 400,000 to 500,000 bbl/day remained--to supply civilian and military demands"[40] (See Figure 4) until 1944. Railroad deliveries began to taper off; and even though a high degree of coordination had been developed, deliveries themselves were rather irregular. For example, tank car deliveries averaged 840,000 bbl/day during September, 1942, but only about 750,000/day during October.[41] "With other war work making claims upon the roads, oil schedules became more difficult to maintain, and the tank cars themselves were increasingly laid up for repairs."[42]

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[39]"War Transportation System Revolutionized to Meet War Conditions," World Petroleum, XIII (November, 1942), p. 42.

[40]"Transportation Changes to Meet War Conditions," op. cit., p. 37.

[41]Business Week (November 7, 1942), p. 20.

[42]Fortune, loc. cit.

The point should not be overlooked that in the search for substitutes to fill the immediate supply gap, other transportation facilities were taken into account and were integrated into the immediate transportation scheme as far as possible. The existing pipeline system, for instance, was revamped so that it might more advantageously fit into the transportation pattern. (See Figure 4) To increase deliveries to the East, carrying capacity was enlarged; in some cases, direction of flow on lines was reversed, and other lines were converted from crude oil service (3,200 miles of line). In addition, 2,300 miles were salvaged from systems that were serving less useful service.[43] As the war progressed and demands increased, "the forecasts of future needs showed clearly that no combination of the existing facilities could possibly meet all of the demands that were coming."[44] The need for new construction seemed inevitable, and in the pipeline was seen the possibility of fulfilling this need.

Certain inherent advantages made the pipeline a suitable facility for war transport, and the realization of the advantages was probably a weighted factor in influencing pipeline expansion. Below are a list of the inherent advantages as enumerated in A History of the Petroleum Administration for War.

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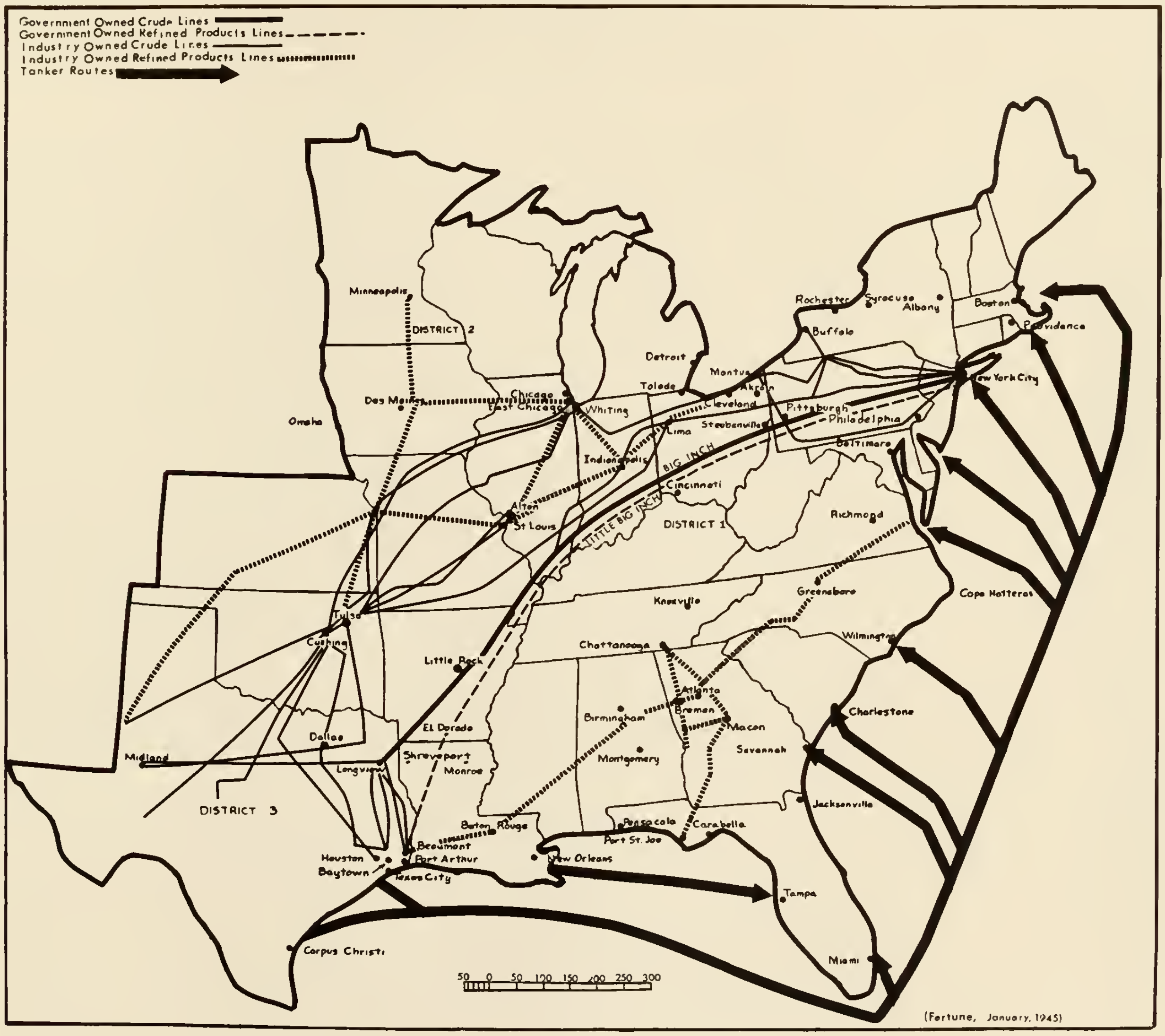
[43] Jones, op. cit., p. 31.

[44] Frey and Ide, op. cit., p. 100.



EASTERN STATES PIPELINE SYSTEM
Figure 4

> Its advantages, particularly in wartime, were many: more work per pound of materials, 24-hour-day service, virtually unaffected by the weather, requiring very little manpower for operation, and immune to submarines.[45]

Due to the limitations of this paper, a detailed presentation and discussion of each project involved in pipeline development and expansion is prohibited. However, in the pages below the author hopes that he can create for the reader a general concept of wartime pipeline development through the presentation of an overview of the course which such expansion and development followed.

<u>A Summary of Pipeline Expansion</u>. As early as the first months of 1941 when the petroleum shortage first became apparent, large East Coast oil companies suggested the possibility of building large volume pipelines from Texas to the Atlantic. That is, if the government would aid them in securing necessary priorities, materials, and rights of way in those states where the laws of eminent domain detained construction. The development of the petroleum shortage encouraged government officials, such as President Roosevelt and Petroleum Coordinator Harold Ickes, "to urge speedy legislation giving pipelines authority to condemn rights of way and offering financial aid to new construction if needed,"[46] and even to authorize government ownership.

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[45] <u>Ibid</u>.

[46] "For More Pipelines," <u>Business Week</u> (May 24, 1941), p. 8.

Private oil interests had already proposed the construction of two lines in the southeastern United States so as to "assure a dependable source of petroleum products . . . in the event they should develop an interruption of ocean tanker movement to the Atlantic Seaboard ports by reason of any national emergency."[47] The two lines were the Southeastern line which was to extend 465 miles from Port St. Joe, Florida, to Chattanooga, Tennessee, and the Plantation line, a 1,261 mile line from Baton Rouge, Louisiana, to Greensboro, North Carolina. (See Figure 8) In the construction of these lines, the pipeline companies ran into one basic problem, and that problem was the acquisition of rights of way. Laws of all states involved except Georgia and South Carolina allowed to pipelines the right of "eminent domain." To overcome this problem, congress was persuaded to pass the Cole Act in 1941--an act which entitled oil companies to condemn land and acquire rights for petroleum pipelines essential to the national defense, upon certification of the President.[48]

To aid the coordination of petroleum flow, an Office of Petroleum Coordination for National Defense was created in May, 1941. This office, under the direction of Harold Ickes, in conjunction with representatives from the petroleum

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[47]Hearings Pursuant to House Resolution 290 and House Resolution 15, p. 80.

[48]See Hearing Pursuant to House Resolution 290 and House Resolution 15 and 188.

industry, formed the Petroleum Administration for War. The P.A.W. sponsored 27 projects, of which 21 were financed by private companies and six were sponsored by the government. In total the government spent $187,000,000, and private industry spent $69,000,000 on the development of these various projects which involved the construction of "approximately 4,000 miles of new line, the reversing and converting of some 3,250 and the dislocation of another 3,250 miles.

Of all the projects undertaken, probably the most noted were the Big Inch projects, which involved the construction of a 1,254 mile 24" crude oil line from Longview, Texas, to the New York-Philadelphia area, and a 1,475 mile 20" products line from Beaumont, Texas, to New York-Philadelphia.[49]

The first of these lines, the Big Inch line, was begun in June, 1943. Due to a shortage of steel (only 137,500 tons was allotted), the first section was laid to Norris City, Illinois, where it served as a supply source for tank trains moving to the Eastern seaboard. "The loading terminal at Norris City consisted of over a mile of loading racks with seven miles of railroad tracks to serve."[50] The tank cars loading at Norris City reached a peak of 1,250 cars/day in

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[49]See Table 4

[50]"Emergency Pipelines--Their Record in Review," World Petroleum, XVI (June, 1945), p. 47.

TABLE IV

Big Inch
(Some factual data)

Length of Main Line (24" diameter)	1,254 Miles
Feeder and Distribution Lines	222 Miles
Total length of pipe in system	1,476 Miles
Weight of pipe in System	358,000 Tons
Weight of Steel Plate in Storage Tanks	20,700 Tons
Number of pumping Stations including Terminals	28
Number of Main and Branch Line pumping units	81
Number of Auxiliary pumping Units	19
Number of Oil Tanks in System	51
Capacity of Oil Tanks	3,955,000 Bbl.
Volume of Oil Required to Fill Pipe in System	3,836,000 Bbl. 161,112,000 Gal.
Daily Throughput of "Big Inch" Full Load	300,000 Bbl. 12,600,000 Gal.
Annual Throughput of "Big Inch" Full Load	109,500,000 Bbl.

TABLE V

Little Big Inch
(Some Factual Data)

Length of Main Line (20" diameter)	1,475 Miles
Feeder and Distribution Lines	231 Miles
Total Length of Pipe in System	1,706 Miles
Weight of Pipe in System	287,000 Tons
Weight of Steel Plate in Storage Tanks	14,800 Tons
Number of pumping stations including Terminals	31
Number of main and branch line pumping units	86
Number of Auxiliary pumping Units	8
Number of oil Tanks in System	47
Capacity of Oil Tanks	2,860,000 Bbl.
Volume of Oil Required to Fill Pipe in System	2,870,000 Bbl. 120,540,000 Gal.
Daily Throughput of "Little Big Inch" Full Load	235,000 Bbl. (gasoline) 9,870,000 Gal.
Annual Throughput of "Little Big Inch" Full Load	85,775,000 Gal.

early 1943. However, this activity was short lived and by August 14, 1943, the Big Inch line had been extended to the East Coast only 377 days after the first pipe was laid.

The Little Big Inch line, the first section extending from Beaumont, Texas, to Seymour, Indiana, at a cost of $44,000,000, was begun in February, 1943, and was completed in March, 1944, at a total cost of $75,000,000. These lines constructed in record time were three to four times larger in capacity than any built to that time; and by the end of the war, over 316,000,000 barrels of crude oil and refined products had been delivered to the Eastern seaboard through these and other connecting lines.[51]

The expansion and development of this pipeline system had several immediate effects which were self-evident, and possibly some other which were not quite so evident at the time. However, since the purpose of this chapter was basically to create for the reader a descriptive knowledge of pipeline utilization, an attempt to analyze the actual role of the pipeline will not be undertaken here but later in Chapter IV.

The Canol Project

Whereas, the pipeline network of the continental United States served as a means of supply both for civilian

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[51] *Ibid.*, p. 51.

and military demand, in other areas similar facilities were many times developed and utilized largely as a means to a militarily planned end and were little used for supplying civilian demand. The pipeline system that was developed in North West Canada, the Canol Project, was an example of such a system.

Of all the pipeline projects initiated during the war, the Canol project is probably the most controversial from the standpoint of necessity and the roll it actually played, and was subject to several governmental hearings during the time of its development and afterward. In the discussion herein set forth, it is not the purpose of the author to judge whether the project was right or wrong, but rather to present as near as possible, in a brief summary, an accurate picture of the project from a descriptive point of view. And in so doing, it is hoped that an understanding of it as a facility utilized for the spatial movement of commodities can be developed. In painting this picture, the following topics will be examined: the war situation and the dislocation of commodity flow, the background and development of Canol, and the utilization and abandonment of the project.

<u>The World Situation and the Dislocation of Commodity Flow</u>

> The sole justification sought to be advanced for the Canol project [according to the War Department] was military necessity, based on military appraisal in the Spring of 1942 of the war situation and the early need for oil products in the Alaskan area.[52]

The war in the Pacific began in December, 1941, with the bombing of Pearl Harbor and within the next few months Guam, Wake, the Philippines, the East Indies, Singapore, and portions of Burma fell under the control of Japan. This meant a loss to the allies of the strategically important oil fields of the Far East. During the same period, the Germans, as was pointed out previously, intensified their submarine activity in the Atlantic, Gulf, Caribbean, and Pacific. With the dislocation in shipping in the coastal areas of the Atlantic and Pacific, an increased demand on available ships for overseas service, and the movement of the Japanese northward in the Pacific seizing control over Attu and Kiska in the Aleutians, it appeared that the northwest coast of North America could possibly be in danger. And if such a situation did develop, it would be necessary to effectively supply fuel for the planes, ships, and military equipment used in the Alaskan Theatre. It was in this framework of events that the plans for the Canol Project were formulated.

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[52] Investigation of the National Defense, Special Committee Pursuant to Senate Resolution 71, 77th Congress, and Senate Resolution 6, 78th Congress. "The Canol Project," Report 10, part 14.

The Background, Plan and Development of Canol. The Canol Project was based largely upon the idea that an oil reserve capable of meeting the military needs of the Alaskan Theatre was present in the Canadian North West Territory. Oil had been discovered in the area in 1888, and a number of wells were drilled, beginning in 1918, in the Norman Wells area to supply the local market. The local market was largely confined to supplying local mining operations, airplanes, and riverboats operating in the area. The market area was large, encompassing thousands of square miles, but market in terms of total volume of products was small. For instance, in 1941 only 180,000 gallons of aviation gasoline, 112,000 gallons of motor gasoline, and 230,000 gallons of fuel were marketed from the wells.[53]

With the intensification of the war in the Pacific, two panaceas were suggested for supplying Alaska, which occupied a position accessible only by sea or air. To provide petroleum products, our supply problems encompassed ports, storage roads, and pipelines as well as the availability of the products themselves. In the Spring of 1942, there existed a shortage of petroleum on the West Coast of the United States, a deficiency of tanker supply carrying

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[53] O. B. Hopkins, "The Canol Project," The Canadian Geographic Journal, XXVII (November, 1943), p. 241.

capacity to carry petroleum to Alaska, and a deficiency of ship building facilities for construction of additional tankers.[54] The two panaceas evolved to solve these problems were: the construction of a highway by which commodities could be moved overland from the continental United States to Alaska and the construction of a pipeline system to supply the road, airfields, and shipping facilities.

The logistical plan laid out by the Department of Defense was for the further development of the Norman Wells area and the construction of a pipeline from Norman Wells 600 miles across the Mackenzie-Yukon divide to White Horse on the Alaskan Highway where a refinery was to be built to process the crude petroleum into fuel and other refined products. In addition to the main pipeline, three products lines were to also be constructed (See Figure 5): one from the refinery at White Horse to the port at Skagway to supply ocean-going vessels, a second from White Horse to Fairbanks, and a third to Watson Lake airfield in the Yukon. In constructing these facilities, a number of problems of uncertainty had to be reckoned with. These problems involved estimating how much oil was obtainable from the area and how soon it could be attained, securing personnel and equipment,

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[54]Wallace Everett Pratt, World Geography of Petroleum, Published for the American Geographical Society by Princeton University, 1950, p. 350.

and moving transportation material and equipment over primitive and inadequate facilities in a prescribed period of time. To eliminate the uncertainty of the problem of potential oil supply, Lt. General Brehan B. Somervell, commanding General, Services of Supply, called for the exploratory drilling of nine additional wells in the Norman Wells area. From this exploratory drilling, it was then estimated that from 60 to 100 million barrels of potential oil supply was available for use. However, it was "admitted that not all of this oil might be obtainable since part of the oil-bearing structure lay under the Mackenzie River."[55] With the completion of the exploratory survey and drilling operations, the construction of the project was ordered to begin--to begin without adequate knowledge of the total situation, as the Truman Commission put it.

> The recommendations were made without a survey of the route of the projected pipeline and with no knowledge of the conditions to be met except that mountainous terrain, muskeg, and extremely cold winter temperatures would present very difficult problems; without considering the number of pumping stations to be required; and the most advantageous size of the pipeline for the purposes required; without considering the possible alternative locations of the refinery; without considering the costs and difficulties inherent in transporting the materials and men and maintaining them at the project; and without considering possible alternative methods of obtaining oil products for the Alcan Highway.[56]

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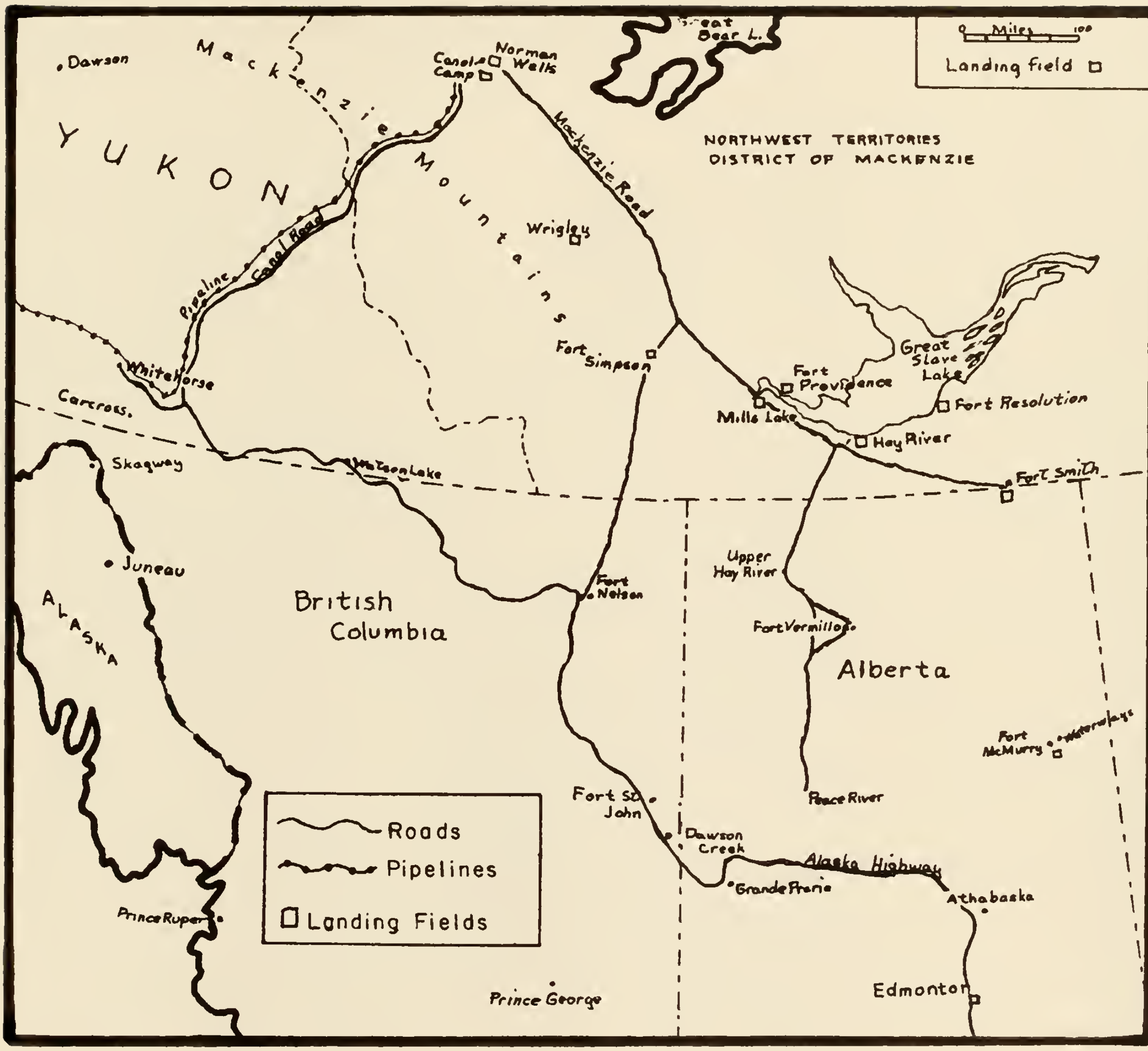
[55]Stanley W. Dzuiban, "Military Relations Between the United States and Canada, U.S. Army in World War Two, 1939-1945 (Washington: U.S. Government Printing Office, 1959), p. 231.

[56]U.S. Senate Special Committee Investigating the National Defense Program. Pursuant to Senate Resolution 71, 78th Congress, 1st session, Senate Report 10, p. 3.



The Canol Pipeline System

Figure 5

In June, 1942, 2,600 task force troops arrived at Waterways, Alberta, 350 miles from Edmonton, to clear the way for the construction of the proposed project. The purpose of the task force was "to establish the transportation system to Norman Wells over which could move the civilian construction organization and supplies needed for construction of the pipeline."[57] Materials were transported 285 miles down the Athabaska and Slave Rivers to Fort Fitzgerald, at which point there was a sixteen mile portage around rapids, and from thence 195 miles down Slave River to Great Slave Lake, 125 miles across the lake to the Mackenzie River, and 550 miles down the river to Norman Wells.[58]

The pipeline itself was begun in the Summer of 1942; and the work of blasting roads, building airfields, and wharves and loading facilities continued throughout the Winter. During construction, the engineers were confronted with several problems peculiar to the northern area: permafrost, muskeg, glacial action, and severe temperatures. Permafrost, or permanently frozen subsoil, could neither be thawed or moved. The only solution was to build over it and insulate it to prevent thaw. The muskeg, or artic swamp area,

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[57]Dzuiban, loc. cit.

[58]Hopkins, op. cit., p. 243.

was avoided as much as possible, but when needful, it was crossed with curduroy, a rock fill, or piling. So-called "glacial action" developed when warm springs that were flowing under a cover of moss and snow would break out to the surface wherever they encountered an obstacle. If the obstacle happened to be a road, the water would accumulate in low spots and consecutive layers of ice would accumulate until all traffic along the road was halted. Sometimes the glaciers were "kept moving through culverts by fires in gasoline drums; sometimes they were blasted out."[59] Because the frostline was about thirty feet underground, it was not feasible to bury the pipe; therefore, it was laid on the surface. An exposed pipeline in an area with extreme winter temperatures created the problem of the control of expansion and contraction and the maintenance of even flow of petroleum. A fortunate factor is that "Artic oil has much of the wax removed naturally in production by the cold earth, and the pour point of Fort Norman oil is about -70°F.[60]

Upon completion in 1944, the Canol Project consisted of a 577 mile long, four and six inch diameter main line, leading from Norman Wells to the Alaskan Highway 80 miles south of White Horse,[61] 1,000 miles of overland road, seven

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[59] Richard C. Finnie, The Subartic Pipeline and Refinery Project (1942-44) (San Francisco, 1945), p. 153.

[60] "The Canol Project Opened," Business Week (May 6, 1944) p. 33.

[61] New York Times, October 13, 2:6, 1945.

full-fledged major airfields and several emergency landing fields.[62] Several supplementary pipelines radiated from White Horse to the southeast, northwest, and south, and a petroleum refinery was constructed to handle 3,000 bbl of oil daily.[63]

The Canol Project: Its Contributions. The final question to be asked, and perhaps the most important one from the viewpoint of this study, is what contributions did the Canol Project make as a supplier of the war effort. This question can be answered from more than one frame of reference. From a restricted point of view, an evaluation may involve only the examination of the actual material contribution in terms of total petroleum products refined and transported during the period of operation compared with the cost of production and operation. When it went into operation, "the Canol refinery was able to process 3,000 barrels of crude oil per day and produce from this crude 479 barrels of aviation gasoline, 1,918 barrels of motor gasoline and 525 barrels of fuel oil."[64] During the first year of operation, 985,000 bbl of petroleum products were produced. In addition to the $134,000,000 initial expenditure on the project, the amount allowed for producing oil

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[62] Richard Finnie, "Epic Canol," Canadian Geographic Journal, XXXIV (March, 1947), p. 139.

[63] Ibid., p. 137.

[64] Dzuiban, op. cit., p. 235.

averaged \$3.70/bbl (\$3,551,790). Imperial Oil Ltd., the operating company, received 20¢/bbl, of which 5¢ was rebated to the governments as rental on equipment, for a net cost of \$144,750. And, in addition to this, \$2.5 million was budgeted for the operation and maintenance of the line, \$2.694 million for operation of the parallel road, and \$3.284 million for operating the refinery. In total, the cost of building and operating the project for one year was approximately \$142,622,750. (The system operated from February, 1944, through June, 1945.)[65] From the viewpoint of economy, it is not surprising that Canol received a great deal of criticism as being a poorly planned project, because in actuality, output of oil and gasoline in its one year of operation was approximately the same amount that ten tankers could carry in the same length of time.

Those that have evaluated Canol from another frame of reference, one that is based on factors other than those of cost and total traffic flow, seem to view the project in a more favorable perspective. The military stressed the point that the project was a strategic logistical move and

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[65]"Retreat from Canol," Business Week (March 10, 1945), p. 24.

"no one should begrudge the fact that the war ended without need of petroleum from Norman Wells to repel attack on the Alaskan mainland, or help fuel the thrust at Japan through Alaska."[66] The move according to this evaluation was "good insurance, nevertheless, and did play an important part in the wartime operation of the Alaska Highway and its airfields."[67] And, even though a full scale military operation in the North Pacific never materialized against Japan, the project did act as a fuel reservoir for Soviet lend-lease planes being used on the European eastern front, and played a role in opening the North West Territory to settlement.

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[66]Finnie, loc. cit.

[67]Ibid.

CHAPTER IV

MILITARY PIPELINES--EUROPE AND ELSEWHERE

The strategic pipeline system of North America discussed in the previous chapter can be classified for the most part as a "logistical" system, a permanent or semi-permanent system constructed to provide large quantities of fuel to a rather stabilized area. However, in many other areas of the world where pipelines were utilized by the allies for the movement of petroleum products, especially in fields of actual military operation, conditions were not always as stabilized. Therefore, "assault" and "tactical" systems rather than permanent "logistical" systems were the most commonly used. An "assault" system is a temporary type system "which can be quickly installed to provide petroleum products to the using elements in assault or rapidly moving combat situations."[68] A "tactical" system is one that can also be constructed rapidly "and is capable of providing sufficient fuel for a corps or army."[69] The factors which differentiate the "assault" and "tactical" type pipelines from the "logistical" are the factors of speed of construction and permanency of use.

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[68]Department of the Army, Military Petroleum Pipeline Systems, Technical Manual 5-343 (Washington, 1962), p. 8.

[69]Ibid.

To facilitate speed of petroleum delivery, it was necessary to develop new methods whereby petroleum lines could be either constructed or dismantled and moved very quickly. The technique developed was the portable military pipeline, an idea conceived by Syd Smith, pipeline chief for Shell Oil Products Pipeline System of New York. The military or portable pipeline which was "used first by the United Nations [Western Allies] in the African Campaign,"[70] was eventually developed into a system more than 10,000 miles in length in all theatres of war, and carried more than 70% of the 50,000,000 gallons of gasoline being delivered to the forces overseas each day.[71] The lines were so designed that an army could pick them up and put them down where it pleased in just a matter of hours, days, or months, depending on length. The flexibility of the line made it easy for the engineers to lay it over hills, through streams or curve it around various obstructions. The typical pipe, which consisted of 20 foot lengths of four or six inch pipes joined by flexible couplings, weighed only 90 pounds per section and was rather easily carried by truck, trailer or even mule-back.[72]

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[70]Frank Love (Ed.), "Invasion Type Military Pipelines," Petroleum Engineer, XVI (April, 1945), p. 164.

[71]Ibid.

[72]"Military Pipelines," Pipeline News, XVI, No. 2 (February, 1944), p. 17-31.

Although the pipelines were portable and were constructed of light weight pipe, there was little if any limitation on the distance which they could be laid.[73] For example, the India-China pipeline, which extended from Calcutta up the Brahmaputra Valley through Assam and Northern Burma into China, used this type of pipeline equipment.

These lines, which were used to transport high octane aviation gasoline, lower grade gasoline and diesel fuel for cars, tanks, jeeps, and other military equipment, were designed so that the pressures could be used to control flow. The flow was controlled in a manner so that, according to Frank Love in the Petroleum Engineer:

> regardless of length, terrain, and other complications, it can be turned off at the delivery point like a garden hose . . . [and] automatic equipment so controls the line that flow of product can be stopped at any point without excessive pressures being built, and immediately upon opening the valve at the point of stoppage flow will be resumed.[74]

Of the many portable or military pipelines utilized, a few bear special mention. Instead of attempting a discussion of each separate individual pipeline in the 10,000 mile Allied system, the author will instead make a representative selection and describe only some of the more notable facilities. The pipeline systems selected for examination herein include:

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[73]Love, loc. cit.

[74]Ibid., p. 166.

the Calcutta-ABC (Assam-Burma-China) line; the POL (Petroleum, Oil, Lubricants) lines operating in Europe; and the PLUTO project (Pipelines under the ocean), a modified version of the standard portable pipeline.

The Calcutta-ABC Pipelines

The development of the Calcutta-ABC pipeline system grew out of the demand for petroleum products perpetrated by the campaign of the Allies against the Japanese in the China-Burma-India Theatre of War. In 1943, "American and Chinese soldiers were slowly pushing the Japanese back through North Burma to remove the threat of a Jap-Axis linkup across Asia, which would have proved disasterous to the Allies."[75] The plan as formulated by the Allies was for a double offensive, moving in on the Japanese from China and India and virtually crowding them out of Southeast Asia. To successfully carry out the plan of advancement, several difficulties, many of them being principally concerned with various logistical problems, had to be overcome.[76]

The forces were for the most part operating in the jungle and mountainous area of North Burma. And, because overland transport facilities were largely lacking in the

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[75]"Building of the ABC Pipeline," Petroleum Engineer, XVI, No. 13 (September, 1945), p. 59.

[76]Charles Romanus and Riley Sunderland, "The China-Burma-India Theatre," The U.S. in World War Two (Washington: U.S. Government Printing Office), p. 306 ff.

area, "air dropping had been their chief source of food, guns, ammunition, and equipment."[77] However, this method of supply proved inadequate since the "Japanese displayed a tenacity which only tanks and heavier guns could overcome without tremendous cost in . . . lives."[78] To overcome these difficulties of movement and to facilitate supply, a logistical plan was formulated for the construction of a road from Lido in Assam, the Lido or Stillwell Road, to Burma where it was to connect with another road, the Burma Road. This road in turn was to join Lashio with Chungking in the Yunnan Province of China, thus opening up the area for penetration from both India and China. (See Map) To build such a road system, bulldozers, trucks, and heavy equipment were engaged, creating an increased demand for fuel products. The demand for fuel products for construction equipment became so great that "by the time the [Lido] Road was at the 50-mile mark, 40 per cent of all transportation over it was trucks supplying this fuel."[79] This, of course, cut down on its capacity to transport other goods; the solution to the fuel supply problem was the construction

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[77] "Lido Pipeline a Tribute to American Engineers," op. cit., p. 6

[78] Ibid.

[79] "World's Longest Oil Pipeline," Op. cit., p. 6

of a pipeline to supply both the troops and the roadbuilders in the forward areas.[80] (See Figure 6)

Construction of the India-China Pipeline. The pipeline constructed was divided into two sections. One section was a six inch line which extended from the storage terminals in Calcutta, where tankers delivered oil and aviation fuel from the Middle East and other regions, "to Tinsukia, in northern Assam, approximately 750 miles, where it emptied into a large storage terminal."[81] The second section "consisted of two 4" lines starting at Tinsukia and ending at Kunming, China . . .."[82] This second line was eventually used to collect petroleum products both from the terminal at Tinsukia and the northeastern Assam petroleum field near Dighoi and move these products to points of distribution along the Lido and Burma roads.[83]

Even though the India-China line was constructed of light-weight portable invasion pipeline like that first introduced in North Africa and later employed in Italy,

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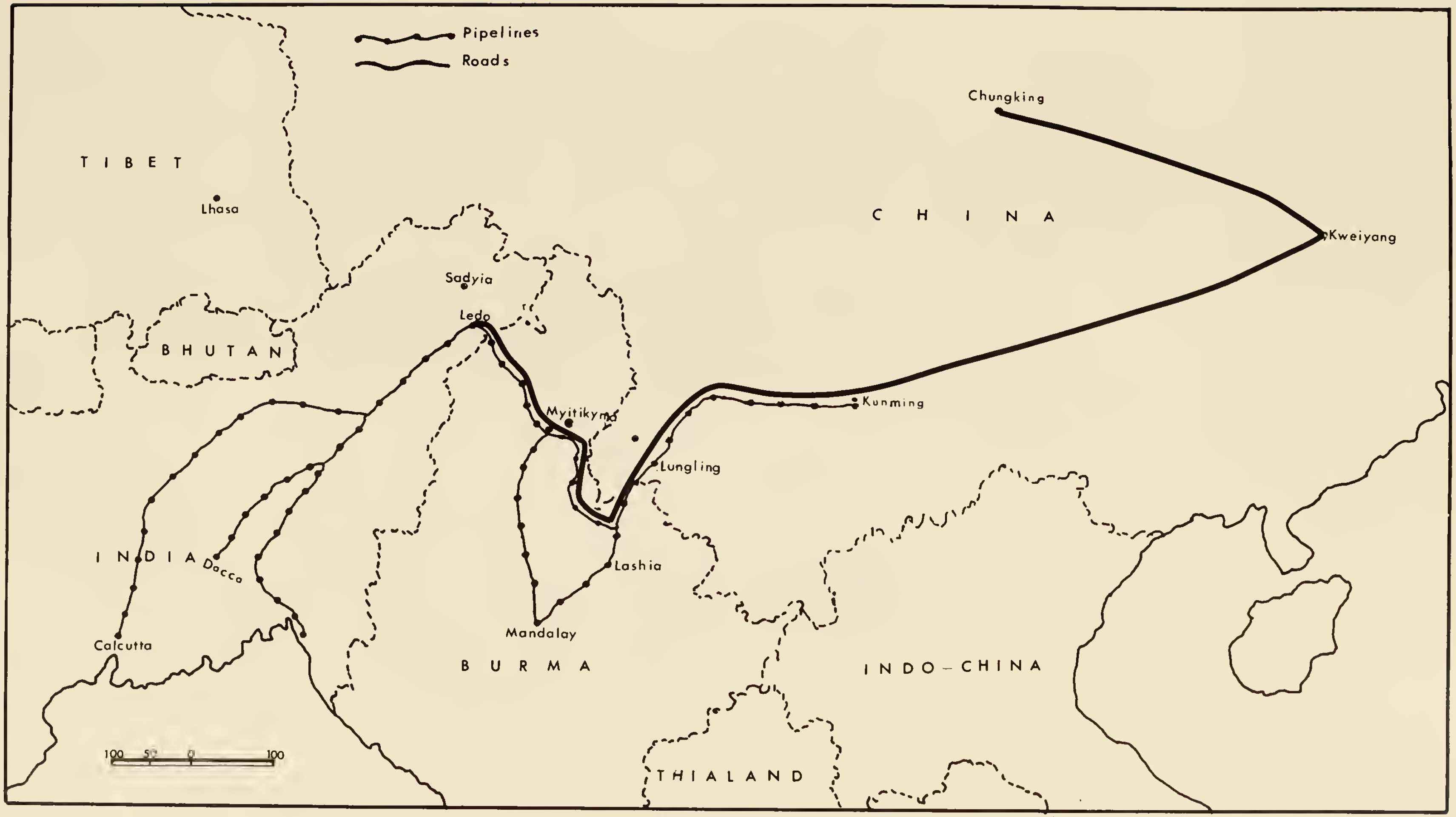
[80]A pipeline to China had been authorized by the Quebec Conference in August, 1943, but the order to construct a line was not given until the construction supply problem developed.

[81]"World's Longest Pipeline," Pipeline News, XVII (May, 1945), p. 18.

[82]Ibid.

[83]This second was never actually completed to Kunming, but it did extend into the Yunnan Province.



THE LEDO-BURMA ROAD AND ASSOCIATED LINES (Pipeline News, Vol 17, No 5, May 1945, P. 22)

Figure 6

France, and other areas of Western Europe, the problems of construction encountered and the engineering technology employed was quite different. In fact, the role of man in the construction of the line itself seems to be a rather remarkable achievement in light of the many problems and engineering difficulties that had to be overcome before its completion. The line was built "over rivers that had never been bridged, over hills that towered 9,000 feet, and over swamps that had never been pierced by any but wild animals."[84] And this was done in spite of "the torential monsoon rains, the limited facilities, the difficult communications, and the shortage of personnel."[85]

The India-China System as a Facility for Commodity Flow. The author feels that the important objective here, however, is not to place emphasis on the technology of construction *per se*, but rather to emphasize the system basically from the viewpoint of its use as a facility for commodity flow.[86] In its capacity as a facility for commodity flow, the system played a three-fold role: (1) as a support facility; (2) as an implement for the redistribution of commodity flow; (3) as a direct source of fuel to the field of military operations.

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[84]"World's Longest Oil Pipeline," *Mining and Metallurgy*, XXVI, No. 465 (September, 1945), p. 428.

[85]"World's Longest Pipeline," *op. cit.*, p. 20.

Just as the building of the Lido-Burma roads were deemed necessary by the military logisticians before the Japanese could be driven out of northern Burma, "so was the pipeline necessary before the road could be completed to do its job."[87] In its capacity of supplying the construction crews operating the bulldozers, trucks, and other heavy equipment, the pipeline became an implement of support contributing to the completion of another logistically planned supply facility, a road. The need for such a support facility was probably the primary incentive behind the initial order to begin work on the pipeline, even though the plan for such a pipeline had been formulated earlier at the Quebec Conference.

In its role as an implement for the redistribution of commodity flow, the pipeline had the effect of displacing "planes and road transport from the heavy chore of carrying gasoline,"[88] and in so doing released these facilities so that they could be utilized for carrying other goods. For instance, "the maximum output of the two 4" lines [was] nearly equal to the carrying capacity of 400 cargo trucks."[89]

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[87]"World's Longest Oil Pipeline," loc. cit.

[88]"World's Longest Pipeline," op. cit., p. 14.

[89]Ibid., p. 18.

In any twenty-four hour period, the lines had the possibility of delivering 8,000 barrels or 336,000 gallons of fuel. The potential carrying capacity that was released could then be diverted to hauling guns, ammunition, food, and other essentials. Moreover, it was possible for them to refuel from the pipelines as they traveled instead of carrying fuel with them, this also creating additional capacity for the movement of other commodities.

Finally, the pipeline fulfilled the role of being a direct source of fuel to the fields of actual military operations. In this capacity, the pipelines, in the early stages of their development, carried fuel to the various distribution centers and airfields of the Northern Combat Area Command. In May, 1944, "the first aviation gasoline arrived at the strategic air base of Shingbwiyang,"[90] and by the middle of June, "100-octane gasoline was being furnished to fighter planes and bombers at every airstrip then in the combat zone."[91] While the north Burma campaign was still in progress, the engineers were planning the final extension of the system into China. This final link was constructed by crews working simultaneously from both Burma and China.

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[90] "World's Longest Oil Pipeline," loc. cit.

[91] Ibid.

"Simultaneous work on the pipeline from both directions was a necessity because the pipeline engineers could not by-pass the men doing the actual fighting."[92] The final section of the line was completed in the early spring of 1945, and "the first gasoline arrived at a major Chinese-American air base in China on April 9, 1945,"[93] approximately eighteen months after the initial construction of the 1800 mile line was begun.[94] (See Table 6 for total delivery made by pipeline to China.)

<u>Europe--The POL Lines</u>

It was, however, on the western front rather than in the China-Burma-India theatre that the military pipeline was first used as a tool of logistic strategy. In fact, it was here that the portable invasion type line was introduced. As the war progressed through North Africa, Sicily, and Italy, pipelines were used to lessen the strain on the limited motor and rail facilities. "Movement of the vast quantities of 100-octane gasoline for tanks and vehicles was possible only because of pipelines, since neither tank cars nor tank trucks were available in sufficient numbers."[95]

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[92] "Building of the ABC Pipeline," <u>op. cit.</u>, p. 61.

[93] "Lido Pipeline A Tribute to American Engineers," <u>op. cit.</u>, p. 9.

[94] For a summation of total gasoline deliveries by pipeline to China in the latter stages of the war, see Table 6.

[95] Joseph Bykofsky and Harold Larson. "The Transportation Corps: Operations Overseas," <u>The U.S. Army in World War Two</u> (Washington: U.S. Government Printing Office, 1957), p. 226-227.

TABLE VI

Gasoline Deliveries by Pipeline to China
In Gallons
(1945)

Month	100-Octane	Motor Gas	Total
April	122,072		122,072
May	671,440	843,000	1,514,440
June	138,919	1,278,200	1,417,119
July	1,684,130	1,495,200	3,179,330
August	1,873,760	1,113,735	2,987,495

In southern and central Italy, for instance, pipelines were constructed inland across the mountainous terrain "to supply the American and the British 8th Army during the Italian campaign."[96] In order to facilitate speed of construction, pipelines were laid on the surface; and all available equipment, including "Italian storage tanks left behind by the retreating Nazi, were rebuilt and additional portable tanks were constructed."[97]

Deliveries of petroleum products were made by pipeline from Taranto, Bari, and Manfredonia in the southeast to Allied airfields in the Foggia area, while other lines were constructed inland from Naples to supply the troops on the west coast. Both four inch and six inch portable lines were used. The four inch had a capacity of 4,000 bbl. of gasoline/day and the six inch almost 12,000 barrels/day. "By December 22, 1943, gasoline was being pumped over two pipelines from Naples to Calni Risorta twenty-five miles beyond."[98] The capacity of the dual line system was 260,000 gallons/day, which filled the requirements of the Fifth Army. "During January, 1944, the utilization of this double pipeline saved an average of 50 railway cars daily, or from 250 to 300 trucks."[99]

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[96]"Building of the ABC Pipeline," op. cit., p. 64.

[97]Ibid.

[98]Bykofsky, op. cit., p. 277.

[99]Ibid.

POL Supply. It was not until the period after D-Day, however, that the European military pipeline system had its greatest facility development, and that as a part of the POL Supply system.[100] The POL (Petrol, Oil, Lubricants) supply system for Western Europe was conceived as part of operation "Overlord," the code word which came to be applied to the general concept of a cross-channel invasion in 1944. "POL alone accounted for one quarter of all the tonnage transported to the European Theatre of Operations."[101] And because of this, it is not surprising that "POL supply enjoyed pre-eminence in the planning and preparation for overlord matched only by the plans for port reconstruction."[102]

A chief focus point in planning the supply of POL was the possibility of utilizing lightweight pipelines that could be constructed rapidly and that would supply a constant flow of "petrol" to the invading troops. Planning for such a system began as early as 1942, but it was not until late in 1943 that a clear outline began to emerge. The outline called for a bulk breaking point at Port-en-Bessin, a Frency city which lies between Cherbourg and The Havre on the English Channel. Here POL was to be moved from tankers via ship-to-shore

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[100] POL: British army jargon for "Petrol, Oil, Lubricants."

[101] Roland G. Ruppenthal. "Logistical Support of the Armies. The European Theatre of Operations." The U.S. Army in World War Two, 2 Vols. (Washington: U.S. Government Printing Office, 1953), p. 319.

[102] Ibid.

pipeline to storage facilities on shore or by a single four inch pipeline to St. Lo. A similar bulk breakpoint was planned for Cherbourg from which POL was to be delivered southward via three six inch pipelines to La Haye-du-Pints, Avranches, and Laval, then eastward via two six inch lines to La Mans.[103] This routing was, however, changed somewhat to conform with changes in the tactical strategy of the overlord military campaign. (See Figure 7)

"On D-Day the first wave of motorized equipment was fueled on the beach from big fifty-five gallon drums."[104] But this condition was only temporary, as engineers soon constructed pipelines from tankers lying off-shore to big storage tanks being set up on or near the beach head. After the storage tanks were set up, the engineers began the task of laying pipelines inland. The laying of the lines progressed at a somewhat slower rate than planned. "Quite frequently the work was done under gunfire and air raid attacks [and] the crews were never certain just when they would explode a hidden mine along the right-of-way."[105] Secondly, because

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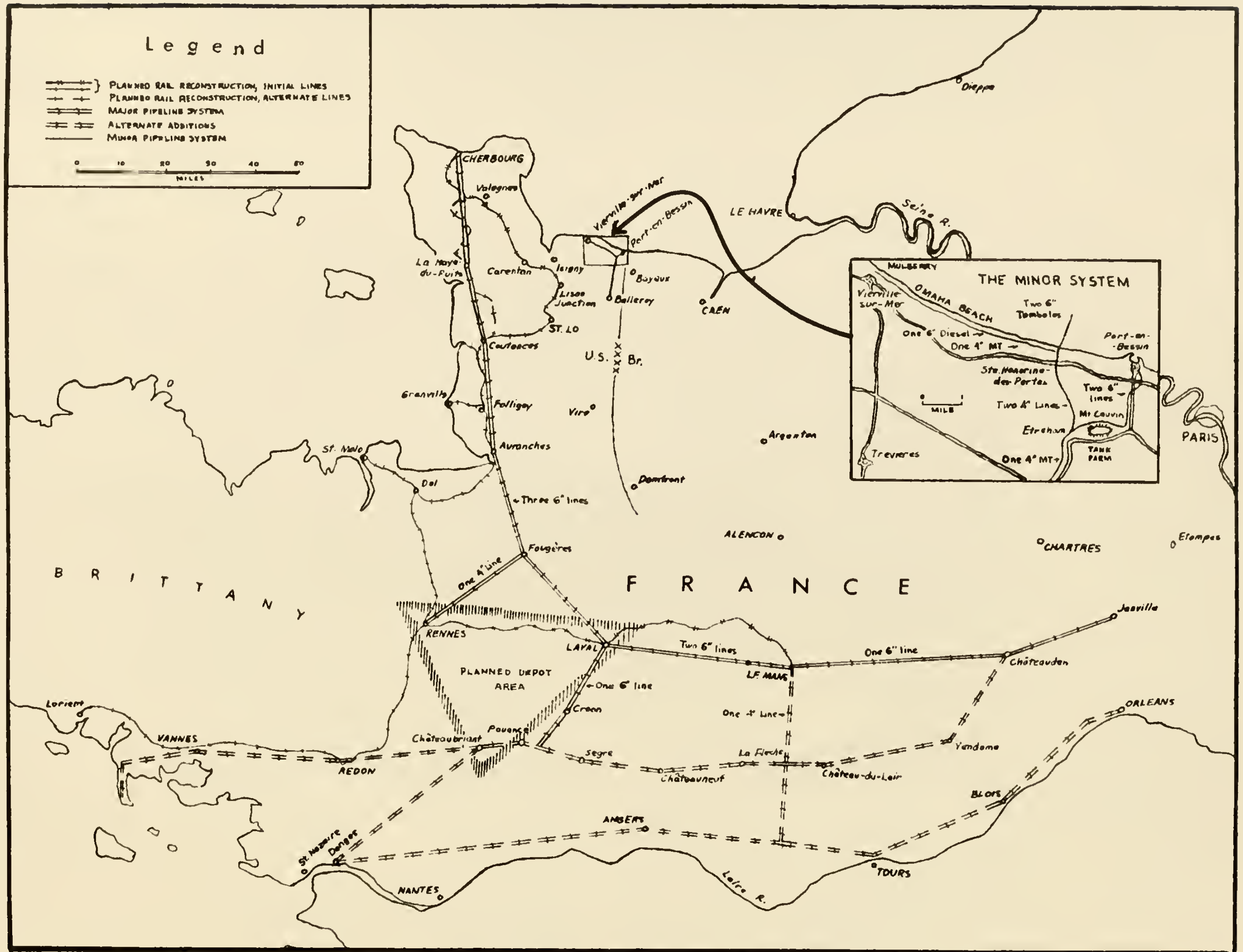
[103]See map of Overlord Plan.

[104]"POL: Gasoline and Oil Carried Right up to Front Lines in Europe," New Yorker, XX (September 23, 1944), p. 16.

[105]W.C. Platt. "Pipelines in France Created Under Fire Sheds Growing Pains," National Petroleum News, XXXVII (January 10, 1945), p. 16



Overlord Rail and Pipeline Plan (Source: U.S. Dept. of the Army)

Figure 7

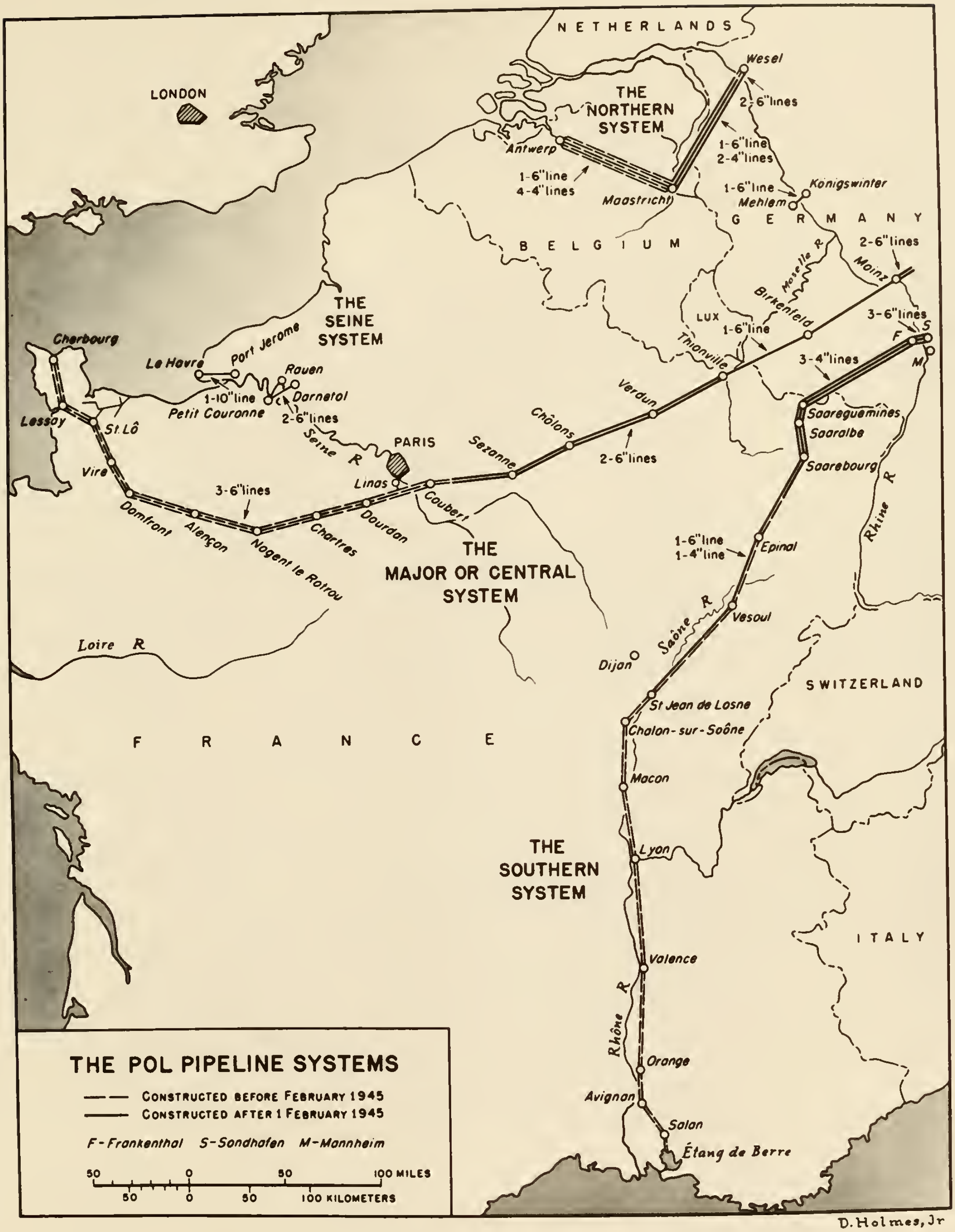

THE POL PIPELINE SYSTEMS
CONSTRUCTED BEFORE FEBRUARY 1945
CONSTRUCTED AFTER 1 FEBRUARY 1945
F-Frankenthal S-Sondhofen M-Mannheim
50 0 50 100 MILES
50 0 50 100 KILOMETERS
THE NORTHERN SYSTEM
THE SEINE SYSTEM
THE MAJOR OR CENTRAL SYSTEM
THE SOUTHERN SYSTEM
NETHERLANDS
BELGIUM
GERMANY
LUX
FRANCE
SWITZERLAND
ITALY
LONDON
PARIS
Wesel
Antwerp
Maastricht
Königswinter
Mehlem
Mainz
Birkenfeld
Thionville
Verdun
Châlons
Sezanne
Coubert
Linas
Dourdan
Chartres
Nogent le Rotrou
Alençon
Domfront
Vire
St. Lô
Lessay
Cherbourg
Le Havre
Port Jerome
Rouen
Darnetol
Petit Couronne
Saareguemines
Saaralbe
Saarebourg
Epinal
Vesoul
Dijon
St Jean de Losne
Chalon-sur-Saône
Macon
Lyon
Valence
Orange
Avignon
Salon
Étang de Berre
Seine R
Loire R
Moselle R
Rhine R
Saône R
Rhône R
2-6" lines
1-6" line
2-4" lines
4-4" lines
1-6" line
3-6" lines
3-4" lines
1-10" line
2-6" lines
1-6" line
1-4" line
D. Holmes, Jr

Figure 8

of the limited supplies moving into France and the variety of demands from different sources for these supplies, "the pipelines had their troubles in locating their equipment and getting it to where it was needed on time and with no parts missing."[106] But in spite of these difficulties, "when the first allied troops entered Paris, the pipeline was only thirty-five miles behind them."[107]

Figure 8 shows the total POL pipeline systems constructed before and after February, 1945. The five separate systems within the larger total POL system included: the major or Central system which entended south and east from Cherbourg to St. Lo, Chartres, Coubert, Thilonville, and finally to Manz on the Rhine; the southern system from Etang de Berre in southern France north and east to Frankenthal, Sandhofen, and Mannheim on the Rhine; the minor system which connected Port-en-Bessen with St. Lo and the major line; the Seine system composed of a number of short connecting distribution lines along the Seine River; and, the Northern system with its terminal point at Antwerp in Belgium extended southeast to Maastricht and then north and east to Wesel on the Rhine.

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[106] Ibid.

[107] POL; Gasoline and Oil Carried Right up to Front Lines in Europe," loc. cit.

"On its completion, the continental network--including the Seine and Minor systems . . . had a route distance of 1,412 miles and had 3,477 miles of pipe. Storage facilities totaled 7,619,116 barrels."[108] Each of these lines, for the most part, followed the movement of allied troops, carrying both high-octane aviation fuel, tank fuel, and lower grade gasoline and diesel fuel for automobiles, jeeps, and bull-dozers.[109]

The typical flow pattern was somewhat similar for each of the lines. The POL products were first moved into coastal areas via tankers, at which point a break in the flow pattern occurred, and the products were transferred to shore via ship-to-shore pipelines where they were deposited in large storage tanks. From here the products were pumped through the long-distance military lines into the front areas. "Somewhere near the front, the fuel. . . [was] pumped into drums or tank trucks as conditions required."[110] There were, as might be expected, deviations to the standard flow pattern. For instance, in the areas of western France that were served by operation PLUTO, POL products were pumped through pipelines across the channel, thus omitting the tanker ship-to-shore

[108]Ruppenthal, op. cit., p. 438.

[109]Lubrication oil was too heavy to be sent through pipelines.

[110]"POL; Gasoline and Oil Carried Right up to Front Lines in Europe," loc. cit.

operation. In the later stages of the war, before the six inch Thilonville-Mainz line was completed, POL was transferred from pipeline to tank truck at Thilonville or Birkenfeld and carried by tank truck to the Rhine River where it was pumped across the Rhine through two six inch pipelines to the field of operations.

Operation PLUTO

In planning POL deliveries to the continent, the Allies also considered the idea of developing submarine pipelines to span the English Channel. The United States Corps of Engineers and the British both conducted experiments with underwater petroleum movement. However, the United States submarine pipeline experimentation project was abandoned, and it was the British who "developed cables that could be laid underwater and that would carry POL under high pressures."[111] Lord Louis Mountbatten, head of combined operations, first suggested the idea in 1942, when he asked Geoffrey Lord, British Minister of Petroleum Welfare, if a line could be laid across the Channel.[112] There was some doubt if such an operation could be performed. Nevertheless, experimentation was begun and two new types of line were

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[111] Ruppenthal, op. cit., p. 323.

[112] "Operation Pluto," Oil and Gas Journal, XLIV (June 2, 1945), p. 56.

developed specifically for the submarine channel operations. The Hais cable, a three inch hollow cable, "something like a submarine electric power cable but without cores and insulation"[113] was capable of operating under pressures of more than 1,200 lb/sq. inch. "The fact that the cable was hollow increased the difficulties [of laying it] for it was likely to kink and so stop the oil flow."[114] To minimize kinking, cables were inflated with water before they were laid.

The second submarine type line was the Hamel welded steel pipe, a lightweight pipeline composed of 20 foot lengths of three inch diameter steel welded into lengths of 4,000 feet. To lay these pipes, a floating drum "capable of carrying the full length of pipe required for the channel crossing."[115] The floating drums, called "conundrums," were 90 feet long, more than fifty feet in diameter, and when fully wound with pipe weighed 1,600 tons, or approximately the weight of a destroyer.[116]

When the testing of the submarine pipes had proved successful, tentative plans were formulated to lay ten three

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[113]"Pipelines for Pluto," Welding Engineer, XXX (July, 1945), p. 49.

[114]"Operation Pluto," Petroleum Engineer, XVI (June, 1945), p. 170.

[115]"Pipelines for Pluto," op. cit., p. 50.

[116]J. E. Oldham, "Operation Pluto," Engineering and Contract Record, LVIII (July, 1945), p. 77.

inch cables from the Isle of Wight to Cherbourg, the first line to arrive 12 days after D-Day. In its final revision, operation PLUTO included 21 lines. (See Figure 9) Force PLUTO with its homebase in Southhampton and Tilbury was connected with the 1,000 mile pipeline system of Great Britain. The fuel was carried from the British system to the coast where special high pressure pumping stations, cleverly camouflaged, were used to pump the petroleum through the submarine system to the continent.[117]

On August 12, 1944, within a few days after D-Day, operation PLUTO officially began with the laying of lines from the Isle of Wight to Cherbourg on the French coast. But these lines were only of short duration and were abandoned "when the Allied Armies rapid advance along the French coast made it necessary to concentrate all efforts on the Dungeness crossing."[118]

The second group of lines were laid across the narrowest part of the channel and connected Dungeness on the British

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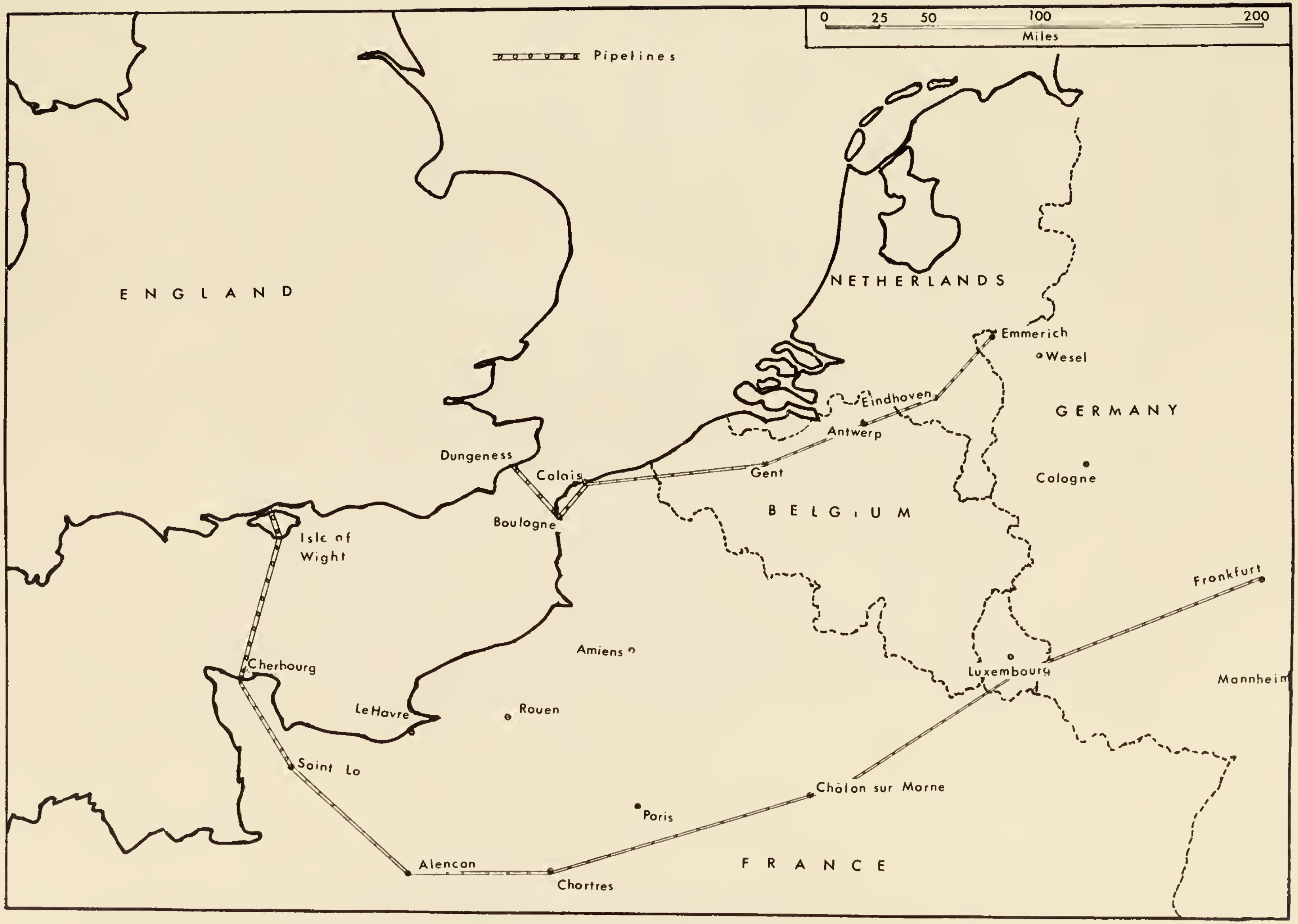
[117] One pumping station "was in a row of blitzed houses at Sandown, on the Isle of Wight; another was in an old fort built in the 1860's against possible invasion by Napoleon III, and others were in a modern amusement park and in seaside villas at Dungeness." "Operation Pluto," <u>Petroleum Engineer</u>, (June, 1945), p. 174.

[118] "Pluto," <u>Institute of Mechanical Engineers, Proceedings</u>, CLIV, no. 4 (1946), p. 437.



The Pluto System and Connecting Lines
Figure 9

Petroleum Times, June 9, 1945

coast with Boulogne on the French coast. Each one of the three inch lines could deliver about 120,000 gallons, or 400 tons, a day. "Eventually eleven Hais and six Hais-Hamel lines were laid with a capacity of more than 4,500 tons, or 1,350,000 gallons a day; and 1,000,000 gallons a day were pumped across for many weeks."[119] At Boulogne PLUTO made connections with other lines (See Map) through which petroleum products were pumped to Calais, Ghent, and Antwerp where it joined the northern POL system.

In its role as a facility for supply, the PLUTO system was less conspicuous, and by being so was less vulnerable to air attack than the tankers traveling the Channel route. However, the Allies were cognizant of the fact that a last moment rush of submarine activity might damage or destroy the lines, and kept duplicate lines in reserve to replace any that might be damaged or made inoperative.
From August 12, 1944, to May 8, 1945, PLUTO was responsible for supplying about 120,000,000 gallons of gasoline to the Allies in Europe. In the words of the Quartermaster-General, PLUTO not only supplied the forces of Europe, but it was also employed as a facility for tanker displacement. An in so doing

> it saved a very large tanker tonnage which was badly needed in the East. Thus PLUTO had a reaction which extended all over the world.[120]

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[119] Ibid., p. 438.

[120] Ibid.

CHAPTER V

THE PIPELINE--AN INTEGRAL PART OF THE TOTAL TRANSPORTATION SCHEME

In this chapter, an attempt will be made to analyze the overall role of the pipeline in terms of its character and its utilization. Up to this point, much of the material presented has been of a descriptive nature, and little attention has been paid to the salient characteristics which contribute to the suitability of the pipeline as a facility for commodity movement. In the paragraphs below, the author has compiled a brief listing of some of the characteristics.

Salient Characteristics of Pipeline Transport

According to the Army Technical Manual on Military Pipeline Systems, some of the advantages of moving liquid fuels within the theatre of military operations by pipeline are effectuated by certain characteristics inherent to the pipeline. For example, "adverse weather conditions do not present as many serious problems to pipeline operation as they do vehicular transport."[121] Rain, snow or flood can detain petroleum flow by tank truck or other mobile facilities,

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[121] Department of the Army, op. cit., p. 7.

whereas the pipeline which is a fixed facility is little affected by these elements of nature. However, it must not be overlooked that weather conditions may hinder construction and repair work on the line. Secondly, because of their flexibility, pipelines can be constructed over adverse terrain where major roads or railroads would be difficult to construct. And this construction, particularly where portable military lines are used, can be facilitated much more rapidly than that of the road or railroad because only a minimum of change in the physical landscape is usually needed. Thirdly, pipelines are well adapted to camouflage techniques. They can be located to take advantage of natural cover. As a result, pipelines and their pumping stations are relatively immune to successful air attack.[122] Tank trucks and other vehicular facilities are more open to detection; and if a convoy is attacked and destroyed, the supply line may become virtually paralyzed. If pipelines or their pumping stations are attacked, they can be repaired or replaced more quickly than some other facilities. Since even though several sections can be put out of operation, it would be difficult to destroy the whole facility. If a pipeline is well designed, with sufficient tankage at

[122] Ibid.

intermediate points, line breaks will not necessarily cause complete shutdown of the line. Even marine-terminal installations which might make good targets for enemy attack can be so camouflaged or concealed that risk of attach can be kept at a minimum. The methods employed to conceal the marine-pumping stations of operation PLUTO are exemplary of such camouflage techniques.

In addition to the specific characteristics which make the pipelines suitable for utilization within the theatre of military operations, there are also other characteristics which may affect the pipelines position both in the field of military operations and in other areas as well. First of all, the pipeline makes the handling of flow one simple, continuous operation. Because the handling of oil flow is a rather simple, continuous, and almost automatic operation, little labor or man-hour expenditure is involved. The pipeline which can replace several propelled vehicles and which eliminated the need for drivers to steer these vehicles, demands only a small crew to maintain the pumping stations and/or to repair the line. In a period of total conventional war such as World War Two when the economic distribution of man-hours may be a crucial factor, the minimization of labor demands in the area of pipeline operation

may add strength to other operational areas that have greater labor demands, or may aid in filling a man-hours gap in those areas where there is a labor deficiency.

The directional nature of commodity flow is another factor which should not be overlooked. Vehicular type transportation facilities usually have the ability to carry on a two directional traffic flow; collecting commodities at one point, transporting these commodities to the point of destination, and picking up other commodities and delivering them to the original point of origin or elsewhere. A pipeline is basically a one directional facility. Its very nature would suggest such a situation since liquid can be pumped only one direction at a time through a pressurized pipe. If flow were to occur in the opposite direction, the pipe would have to be cleared of the first liquid; a second liquid product would have to be introduced, and the pumping system would require a reversal. In one perspective, the "one directional" nature of the pipeline can be considered as a disadvantage, for it gives the facility a rigid character, restricting its flexibility of use. From a different perspective, however, "one directional" flow might be considered advantageous. For example, in the coordination of petroleum movement by rail between the southwestern production area of the United States and the Atlantic Coast consuming area, in the early stages of the war, stress was placed on moving

the maximum amount possible in the shortest period possible. To bring about this goal, large numbers of empty tank cars were moved from the consuming areas in the East to the production areas in the West. This necessitated the expensive and time consuming task of transporting unused dead-weight tonnage. The pipeline, of course, with its one directional flow, eliminates such a necessity.

Pipelines may also add a measure of certainty to commodity flow. In a period of war, a rather exact knowledge of potential petroleum transport capacity may be of strategic importance both to the civilian and to the military consumer. The pipeline provides the consumer with both a knowledge of available transport capacity, since it is a fixed facility with a fixed capacity subject to very little flow deviation, and with a knowledge of "where the oil is, and what delivery schedule can and will be maintained."[123] Of course, it should not be overlooked that another prerequisite for certainty of flow is "that there be a fairly large and consistent volume available for an extended period."[124] A mere knowledge of the fixed capacity without a knowledge of the commodities available to move via the capacity will in itself create uncertainty.

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[123] Hugh N. Emerson. "Salient Characteristics of Petroleum Pipeline Transportation," Land Economics, XXVI (1950), p. 38.

[124] Ibid.

A final factor to be mentioned is the factor of cost. In an earlier section, a differential transport cost table was given (See Page 35) in an effort to explain the petroleum flow pattern between the crude oil production regions of the southwestern United States and the consumption areas along the Atlantic Coast. One conclusion that can be drawn from comparing this table with Figure 1 is that in a peacetime situation there seems to be a tendency for commodities to flow via those means of transportation that have the lowest ton-mile costs. However, in a war situation strict monetary costs may be of minor consideration, whereas matters of strategic position may attain precedent so that more expensive supply facilities may be utilized if the logistician feels that such utilization will best contribute to the accomplishment of the established military goal. For example, the justification offered by the military logisticians for the construction of the Canol Project was based on such a concept.

Conclusions

It is evident from the study that the pipeline played not one but a multiplicity of roles in its capacity of supplying the war effort. After examining the material carefully, the author has concluded several important roles

which he believes the pipeline to have played and has arranged these into the following list.

1. Filled a "supply gap" in some areas where there was a displacement or interruption of normal commodity flow.

2. Reduced the "effective distance" of commodity flow.

3. Implemented the redistribution of commodity flow.

4. Acted as a support facility for other modes of transportation.

5. Supplied reserve potential.

6. Contributed to the advancement in design, construction and technology of petroleum transportation equipment.

The reader should remember, in considering each of these roles, that it is not necessarily a separate entity in itself, but at times it may be closely interrelated or almost inseparable from one or more of the other roles.

<u>A Filler for a Supply Gap</u>. The first conclusion was derived from the study of the pipeline system of the United States. When coastal petroleum movement was interrupted and there was a displacement of normal commodity flow, a "supply gap" was created and for a time there was an actual decrease in total quantity of flow between the production and consumption areas. Other facilities of transport, including the pipeline, were substituted, and through this substitution the supply gap was eventually filled.

A Reducer of Effective Distance. Effective distance or transportability, as defined in an earlier section, is the ease of movement in virtue of the type of commodity being moved and the facilities available for its movement. The greater the effective distance, the greater the difficulty there will be in effecting interaction between spatially separated areas. Every pipeline system studied within this paper was in some respect an implement which contributed to the reduction of effective distance. For example, when the effective distance of moving commodities along the coast of the United States was increased with the advent of German submarine activity, the pipeline facilitated a decrease in effective distance by offering a mode of movement virtually immune to the submarine. In Southeast Asia when the factors of isolation, jungle vegetation, and mountainous terrain hindered ground mobility, the pipeline reduced the difficulty of movement by supporting the construction of other transport facilities, by offering a flexible implement for movement across areas where the use of a less flexible implement would have been difficult, and by redistributing commodity flow in such a manner that other facilities could be used more readily for the movement of troops, equipment, and other supplies essential to military operations.

Implemented Redistribution of Commodity Flow. In this capacity, the pipeline performed a dual role. One, it served to relieve the burden placed on other facilities by the increased demands of war. Secondly, it released these facilities to perform other essential supply activities. In Chapter III it was pointed out that war usually creates an increased demand for many commodities. With the occurrence of an increased demand or with the dislocation of supply carrying capacity, some transport facilities may receive a disproportionate share of the total commodity movement. The railroads of the United States, for instance, in the early stages of the war had a rather rapid increase in total freight movement. This increase was probably due to the dislocation of coastal tanker traffic and to the increased demand for equipment supply and troop movement. The pipeline aided in the reduction of this burden by providing a substitute for fuel transportation.

The pipeline not only relieved the burden of increased commodity flow, but also released "a large number of vehicles and personnel for other essential supply activities."[125] In the Italian theatre and in the China-Burma-India theatre, the military pipelines released as many as 400 trucks per day from fuel transport. The release of these trucks and of the

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[125] Department of the Army, loc. cit.

labor required to maintain them provided additional carrying capacity and potential available man-hours to be used in other fields of operation.

<u>A Support Facility</u>. The pipeline also played a two fold role in its capacity as a support facility: (1) It offered support to the construction and operation of other transportation facilities; (2) It became a connecting link between other facilities being utilized for the transport of strategic commodities.

In certain areas, such as Southeast Asia and the North West Territory of Canada, one of the important roles of the pipeline was in offering support to the construction and operation of other transport facilities. For example, in the China-Burma-India theatre, the pipeline supported the construction crews working on the Burma and Lido Roads and was, of course, also utilized for supplying the military convoys moving overland and the various airfields scattered throughout the area. In the North West Territory of Canada, the pipeline system supported in a limited way the trucking facilities operating over the Alaskan Highway, Soviet, American, and Canadian Aircraft, coastal tankers, and other ocean-going vessels operating in the Pacific area. Support such as this was, of course, given in all the other areas

of operation. However, a discussion of each individual area does not seem necessary at this point, so only the above two examples will be given.

In the European Theatre, and in other areas, the pipeline was utilized as a link connecting other integral parts of the total transportation system and promoting a rather even almost uninterrupted flow system. The POL lines were, for instance, connecting links between the tanker service operating along the coast of Europe and the military convoys operating in the interior of France, Belgium, and West Germany.

A Supplier of Reserve Potential. The utilization of the pipelines, in most cases, was an "active" utilization. However, in some specific instances, such as in the Canol system, the pipeline did not serve so much as an active supplier of petroleum commodities, but rather became a reserve source to supply such commodities should the need have arisen. It will be remembered from the study of the Canol system that this project in actuality supplied during its operation only the equivalent of the carrying capacity of ten average-size ocean-going tankers. But, should the need have arisen, the Canol system could have drawn on the 60 to 100 million bbl. estimated reserve of the Norman Wells area.

<u>A Contributor to the Advancement of Petroleum Transportation Technology</u>. Lastly, the utilization of the pipeline in the war contributed greatly to the advancement of petroleum transportation technology. One need only look at each of the systems examined for this to become apparent. It seems largely due to the war that the permanent "large diameter" pipeline first came into use. The possibility of constructing these "Big Inch" lines had been conceived before the war; but it finally became a reality largely due to the pressing demands made by the war.

The demand for the rapid transport of petroleum in the field of military operations offered an incentive for petroleum transportation research; and this research led to the development of the flexible portable military pipeline which could be laid rather quickly over varying types of terrain, and offered an immediate supply to the military theatre.

Finally, the war and the pipeline offered transportation engineers new experience in operating under and adapting to adverse conditions. In the Artic areas the engineers learned to adapt themselves to the permafrost, muskeg swamps, "glacial flow," and extreme temperatures. While in the tropics, they learned to adapt to the dense jungles, the

torrential monsoon rains, and the high temperatures; and in all areas, to rough terrain, rivers, streams, swamps, and various manmade obstructions.

The pipeline has often been overlooked in its capacity as a facility for the transport of strategic wartime materials. Yet this facility has been very important in many ways. It is therefore hoped that through this study the reader has developed a concept as to the importance of the pipeline and the various roles which it played as an integral part of the wartime transportation scheme.

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APPENDIX

GOVERNMENT-INDUSTRY WAR EMERGENCY

PIPE LINE PROJECTS*

Project 1

Increased crude movements north and east from Texas by enlargement of existing systems and reversing of Tuscarora line. Movements to Illinois increased by 40,000 barrels a day, of which 27,000 barrels a day reach eastern refineries. All industry financed at estimated cost of $5,000,000. Work started in 1942, some parts finished in that year; all parts completed in early 1943.

Part A--Texas into Oklahoma: Capacity of Texas Company line from Port Arthur to Stuart, Oklahoma, increased, and line reversed. Capacity of Stanolind line from Graford, Texas, to Healdton, Oklahoma, increased; connecting line to Hewitt, Oklahoma, built by Oklahoma Pipe Line Company.

Part B--Oklahoma and Kansas to Illinois: Capacity of Texas-Empire between Cushing Okla., and Chicago, Ill., increased. Capacity of Stanolind line from Kansas City, Mo., to Chicago, increased. Capacity of Ajax line from Tulsa to Wood River, Ill., increased. Several river crossings replaced by Shell and Stanolind.

Part C--Illinois to East Coast: Capacity of Buckeye line between Mantua, Ohio, and Cooks Ferry, Pa., increased. Illinois Pipeline laid 152-mile 8-inch line parallelling the Lima-East Sparta, Ohio, line. Tuscarora's line between Negley, Ohio, and Bayway, New Jersey, reversed and converted to crude oil service. Capacity of four lines (National Transit, Northern, Tide Water, and Southern) in Pennsylvania increased.

Project 2

Plantation Pipe Line Projects to increase product movement to East. Work started in 1942, completed in early 1943.

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*"War Emergency Projects Account for Bulk of New Pipe Line Work," The Oil Weekly, Vol. 112, No. 9, January 31, 1944, pp. 132-133.

Part A--Bayou Line: Bayou Pipe Line Company constructed 304 miles 10 and 8-inch between Baytown, Texas, and Baton Rouge, Louisiana, to feed 60,000 barrels a day of products to Plantation line. Privately financed at estimated cost of $7,400,000. Contractors: I. C. Little Company on 10-inch between Port Neches and Baton Rouge; O. R. Smith Construction Company on 8-inch between Baytown and Port Neches, and on 6-inch feeders.

Part B--Plantation Capacity Increased between Baton Rouge, La., and Greensboro, N.C., by installation of 14 new booster stations. Capacity increased from 60,000 to 90,000 barrels per day. Privately financed at estimated cost of $4,000,000.

Part C--Construction of 175-mile extension of plantation line from Greensboro to Richmond, Va. Capacity 28,000 barrels daily. Government financed at an estimated cost of $4,500,000.

Project 3

Shipping Capacity from Illinois eastward increased: An 82-mile 8-inch line constructed from Tiffing to Doylestown, Ohio. Capacity 20,000 barrels per day. Government financed at estimated cost of $1,200,000.

A 29-mile extension laid by Standard of Ohio to Randolph, Ohio, to connect with reversed Sun-Susquehanna line between Philadelphia and Cleveland. Capacity 15,000 barrels daily.

Standard of Ohio, Shell and Standard of Indiana made necessary extensions, connections and rearrangements to provide a through products line from Wood River, Illinois, to the East Coast.

Work on all projects started in 1942, completed in 1943.

Project 4

To Increase Pipe Line Capacity in East: All industry financed at estimated cost of $1,700,000. Work started in 1942, completed in 1943. Consisted of following:

Part A--Increased lake tanker movement into Buffalo for delivery through gasoline lines into New York State. Buffalo-Keystone line between Buffalo and Rochester reversed.

Part B--Keystone-Atlantic gasoline line from Philadelphia to Pittsburgh reversed and converted to crude service. Capacity 25,000 barrels daily.

Part C--Construction of 110-mile extension ofSinclair's Philadelphia-Pittsburgh products line to Steubenville, Ohio. That part of line from Schaefferstown, Pennsylvania, to Steubenville, Ohio, reversed to eastward service, Capacity 12,000 barrels a day. Branch from Schaefferstown to Baltimore, Md., was extended to Washington, D. C.

Project 5

Helena Line: Construction of 158-mile 10-inch products line from El Dorado to Helena, Arkansas. Capacity 55,000 barrels a day. Privately financed at estimated cost of $3,700,000. Contractors: Williams Bros. Corp.

Two lines from Port Arthur, Texas, were reversed (one of which was converted) and numerous extensions laid to provide adequate feeder capacity at El Dorado. From Helena products are barged up the Mississippi and Ohio Rivers to the Cincinnati-Pittsburgh area for transshipment by tank car to East Coast. All work completed in 1942.

Projects 6 and 10

"Little-Big-Inch" Products Line: War Emergency Pipe Line, Inc., in 1943 commenced construction of 20-inch products line from Beaumont, Texas, to East Coast. Work almost completed by end of year. Government financed at estimated cost of $75,000,000. Consisted of 1640 miles of new construction, including 61-mile line from Beaumont to Baytown, 60 miles of feeder lines connecting refineries in Baytown area, 51 miles of lines in Beaumont area, and delivery lines in the New York Harbor area. Capacity 235,000 barrels a day of gasoline. Contractors: Williams Bros. Corp.; Sharman & Allen; N. A. Saigh Co.; Winston-Guthrie & Brown; B. & M. Construction Co.; Oil States Construction Co.; Swinerton & Walberg; Sheehan Pipe Line Construction Co.; Midwestern Engineering & Construction Co.; J. C. Truman Construction Co.; Ray L. Smith Construction Co.; C. S. Foreman Co.; Bechtel-Dempsey Co.; O. C. Whitaker Co.; I. C. Little Co.; Oklahoma Contracting Co.

Project 8

"Big-Inch" Crude Oil Line: War Emergency Pipe Line, Inc., 24-inch crude line from Longview, Texas, to New York-Philadelphia area. Government financed at estimated cost of $95,000,000. Started in 1942, leg from Longview to Norris City, Ill., put in operation in January, 1943, and leg from Norris City to East put in operation in early August, 1943. Consists of 1253 miles of 24-inch pipe, 111 miles of 20-inch pipe, and an extensive feeder system. From Phoenixville, Pa., 20-inch extensions to both Philadelphia and Linden, New Jersey, from which points refineries are served by short delivery lines. Capacity of system 300,000 barrels a day. Contractors: Williams Bros. Corp.; Dempsey Construction Co.; Oklahoma Contracting Co.; Anderson Brothers; C. S. Foreman; Sheehan Pipe Line Construction Co.; Ray L. Smith; Betchel & Dempsey; O. C. Whitaker; I. C. Little; Midwestern Engineering & Construction Co.; Exeter Construction Co.; Ford, Bacon & Davis.

To feed the "Big-Inch", War Emergency Pipelines built 50 miles of short links to handle different grades of crude, and four companies (Sun-Stanolind, Pan American, Shell and Atlantic) reversed their lines from East Texas field to Gulf Coast. Several other projects in Texas either feed 24-inch line or replace crude going into it.

Project 12

Trans-Florida Line: A 200-mile 8-inch line built from Carrabelle to Jacksonville, Florida. Government financed at an estimated cost of $4,200,000. Capacity 26,000 barrels a day. Line fed by barge on Gulf Intracoastal Waterway. Work started in 1942, completed in 1943. Contractors: Anderson Bros. laid line; Anderson Bros. and Fredell Construction Co. salvaged and reconditioned pipe from old system in Texas.

Project 13

Sinclair's Corpus Christi to Houston Line: 150-mile 8-inch new line from Corpus Christi to Damon Mound, Texas, to supply Southwest Texas crude to Houston refinery area to replace crude diverted from East Texas to "Big-Inch." Privately financed at estimated cost of $3,000,000. Capacity 25,000 barrels daily. Work started 1942, completed 1943. Contractor: O. C. Whitaker.

Project 14

Texas Pipe Line Company's 266-mile 8-inch and 10-inch new line from Paradis, Louisiana, to Port Arthur, Texas, to bring special Louisiana crudes to Texas' refinery for manufacture of butadiene and 100-octane gasoline. Privately financed at estimated cost of $5,500,000. Capacity 45,000 barrels a day. Work started in 1942, completed 1943. Contractors: Sharman & Allen; N. A. Saigh Company.

Project 15

Products Line from Cushing to Barnsdall, Okla., and Increased Capacity for Great Lakes Pipe Line: 65 miles of new feeder lines from Cushing-Drumright area to Barnsdall to connect with Great Lakes Pipe Line extending to Minneapolis and Chicago. Privately financed at estimated cost of $1,000,000. Capacity 10,000 barrels a day. Line subsequently purchased by Great Lakes company, which handles this additional gasoline through installation of 8 new booster stations between Kansas City, Kansas, and Minneapolis. Completed in 1942.

Project 16

Southwest Emergency Pipe Line: Purchase, reconditioning and conversion to crude serve of 150 miles of 14-inch and 16-inch natural gas line from Refugio to Pierce Junction, Texas. Construction of 26-mile 12-inch extension from Pierce Junction to Deer Park, 8 miles of line to connect with Shell's refinery at Houston, terminal facilities at Houston, and 3 miles of 12-inch line at Refugio. Government financed at an estimated cost of $7,225,000. Capacity 75,000,000 barrels a day. Contractors: O. C. Whitaker; Williams Bros.

Five lines from Refugio to Corpus Christi, Ingleside and Harbor Island reversed or extended to feed Southwest and West Texas crude to Refugio. West Texas crude brought to Ingleside and Harbor Island from Kemper, Texas, through Humble Pipe Line. Crude transported from Houston through reversed Pan American and Shell lines to 24-inch "Big-Inch" line. All work completed in 1943.

Project 17

Sinclair's Houston to Huffman Line: A 29-mile 12-inch new line built from Houston to Huffman. Privately financed at estimated cost of $900,000. Capacity 50,000 barrels a day. Sinclair's line from Huffman to Smiths Bluff, Texas, where it connects with Atlantic's reversed line from Atreco to Longview, reversed. Completed in 1943. Contractor: O. C. Whitaker.

Project 18

Crude Line from Southeastern Louisiana to Baton Rouge: Standard of Louisiana constructed 109 miles of 6-inch, 8-inch and 10-inch main line and 24 miles of feeder lines from Golden Meadows field and other South Louisiana fields to Baton Rouge refinery. Privately financed at estimated cost of $1,500,000. Capacity 15,000 barrels a day. Completed 1943. Contractor: Sharman & Allen.

Project 19

Enlargement of Stanolind's Crude Line Between Mexia, Texas, and Humboldt, Kansas: Installation of additional pumping equipment and 139 miles of 8-inch and 10-inch loops. Privately financed at estimated cost of $1,600,000. Capacity of system increased by 20,000 barrels a day. Completed in 1943. Contractors : I. C. Little; Jones & Brooks.

Project 20

Products Line from East Chicago, Indiana, to Toledo, Ohio: Sinclair has under construction a 250-mile 8-inch 30,000 barrel per day products line. Privately financed at estimated cost of $6,000,000. Line will eliminate tanker movement via Lake Michigan and other waterways to Toledo.

Project 21

Stanolind's West Texas to Drumright, Oklahoma, Line: Construction under way on 385-mile 16-inch crude line from Slaughter field, West Texas, to Drumright, Oklahoma, to connect with existing lines extending north to Chicago and St. Louis refinery areas. Privately financed at estimated cost of

$7,600,000. Capacity 65,000 barrels a day. Seven additional pump stations can be installed to boost capacity to 116,000 barrels a day. Contractors: I. C. Little; Sharman & Allen; Midwestern Engineers; O. C. Whitaker Co.

Project 22

Magnolia's West Texas to Corsicana, Texas, Line: Construction under way on 333-mile 12-inch line from Midland, Texas, to Corsicana, and on two 8-inch loops between Seminole and Midland which aggregate 46 miles. Privately financed at estimated cost of $6,000,000. Capacity 42,000 barrels a day. With installation of three additional stations capacity can be increased to 60,000 barrels a day. Contractors: Jones & Brooks; Williams Bros.; Oklahoma Contracting Co.

Project 23

Yale Pipe Line System in Wyoming and Montana: Construction of 37½ miles of 6-inch and 45 miles of 8-inch crude oil pipe lines connecting the Elk Basin and Frannie Fields with refineries at Laurel and Billings, Montana. Privately financed at estimated cost of $830,000. Capacity 15,000 barrels a day. Project not yet started, but approval given.

Project 24

Stanolind Line from Elk Basin to Casper, Wyoming: Plan 70-mile 8-inch crude pipe line from Elk Basin to Little Buffalo Basin field and 160 miles of 10-inch line from Little Buffalo to Casper, with one 15,000 barrel per day pump station at Elk Basin and one 22,000 barrel per day pump station at Little Buffalo Basin. Privately financed at estimated cost of $4,000,000. Capacity can be increased to 44,000 barrels per day with additional pumping facilities. Construction not yet started.

THE ROLE OF PIPELINES IN
WORLD WAR TWO

by

Charles Wendell Robertson

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AN ABSTRACT OF THE THESIS

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Department of Geology and Geography

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During the course of war, various types of transportation are needed to facilitate the movement of man and materials. One type that is often overlooked is the pipeline. Since it appeared that the pipeline did play a significant part in World War Two, and due to the fact that no general study has been made of the pipeline as a wartime transport facility, it was thought that a study leading to the discovery and evaluation of the pipeline's role in the war might be beneficial. Therefore, through the collection, organization, and interpretation of transportation theory, statistical data, maps, and other information concerning transport in general, and pipelines in particular, such a study and evaluation was attempted.

The following organization was employed in the study. First, an examination was made of the role of transportation in war and of some of the problems encountered in organizing an optimum wartime transportation system. Secondly, a descriptive study was undertaken of some of the more important pipeline systems that were utilized in the war. The study was concluded by an evaluation of the overall importance of the role that the pipeline actually played in light of its character and utilization.

After careful analyzation of the material, it has been concluded that the pipeline played not one but a multiplicity of roles. A summary of these roles are listed immediately below:

1. Filled a "supply-gap" in some areas where there was a displacement of normal commodity-flow.
2. Reduced the "effective distance" of commodity flow.
3. Implemented the redistribution of commodity flow.
4. Acted as a support facility for other modes of transportation.
5. Supplied a reserve potential.
6. Contributed to the advancement in design, construction, and technology of petroleum transportation equipment.